

CORYNEXOCHIDA AND PTYCHOPARIIDA
(TRILOBITA, ARTHROPODA) OF THE
EHMANIELLA BIOZONE (MIDDLE CAMBRIAN),
UTAH AND NEVADA

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ABSTRACT. Trilobites from the *Ehmaniella* Biozone (Middle Cambrian) of the North American craton have received relatively little attention, especially the assemblages of the Great Basin. Described here are several of the corynexochid and ptychopariid trilobites of the *Ehmaniella* Biozone of the Great Basin. Several ptychopariid trilobites from the *Ehmaniella* Biozone are assigned to the new family Ehmaniellidae based on their close stratigraphic occurrence and their morphological similarity in possessing: (1) thin exoskeletons; (2) relatively elongate glabellae with bluntly rounded to rounded frontal lobes, bifurcated F1 lateral glabellar furrows, and converging, relatively straight axial furrows; and (3) micropygous pygidia with poorly defined borders, no or very shallow border furrows, anterior and posterior pleural bands that are moderately convex in exsagittal profile, and pleural and interpleural furrows that join at the border. Ehmaniellidae is further subdivided into two subfamilies, Ehmaniellinae and Altiocculinae. Genera in the Ehmaniellinae include: *Ehmania* Resser; *Ehmaniella* Resser; *Elrathia* Walcott; *Elrathiella* Poulsen; *Parrehmania* Deiss; *Proehmaniella*, new genus; *Pseudomexicella*, new genus; *Trachycheilus* Resser; and *Tympanuella*, new genus. Genera in the Altiocculinae include: *Altiocculus*, new genus; *Pseudoalokistocare*, new genus; and *Schopfaspis* Palmer and Gatehouse.

The stratigraphic ranges of ptychopariid trilobites are used to subdivide the *Ehmaniella* Biozone into four local subzones, which are (in ascending order): *Proehmaniella*, *Elrathiella*, *Ehmaniella*, and *Altiocculus* subzones. These subzones, which are based on shallow-water taxa, are chronostratigraphically correlated with the deep-water faunules of the "*Bathyriscus-Elrathina*" Biozone of the Stephens Formation, British Columbia, Canada, and with other regions in North America.

New genera described here are the ptychopariids *Altiocculus*, *Bathyocos*, *Chanciaopsis*, *Deltina*, *Proehmaniella*, *Pseudoalokistocare*, *Pseudomexicella*, and *Tympanuella* and the corynexochid genus *Opsiosoryctocephalus*. New species and subspecies include the ptychopariids *Altiocculus concavus*, *Altiocculus drumensis*, *Bathyocos housensis*, *Chanciaopsis heteromorphos*, *Deltina angustigena*, *Deltina limba*, *Ehmaniella angustigena*, *Ehmaniella fronsplanata fronsplanata*, *Ehmaniella fronsplanata concava*, *Ehmaniella fronsplanata convexa*, *Elrathiella domensa*, *Elrathiella dugwayensa*, *Elrathiella euthyopsis*, *Elrathiella intermedia*, *Elrathiella rectangularia*, *Elrathina wheelera*, *Glyphaspis concavus*, *Proehmaniella eldoradensis*, *Proehmaniella? granulosa*, *Pseudoalokistocare swasii*, *Pseudomexicella hestia*, *Spencella? utahensis*, *Trachycheilus whirlwindensis drumensis*, *Trachycheilus whirlwindensis whirlwindensis*, *Trachycheilus granulatus*, *Tympanuella transversa*, *Yuknessaspis benningtonis benningtonis*, *Yuknessaspis benningtonis convexus*, and *Yuknessaspis benningtonis planus* and the corynexochids *Dorypyge swasii*, *Kootenia? margoindistincta*, *Opsiosoryctocephalus ophis*, *Parkaspis drumensis*, *Wenkchemnia? housensis*, *Wenkchemnia swasensis*, and *Zacanthoides fronslicinus*. A new subspecies of *Zacanthoides divergens* Rasetti is named *Z. divergens limbus*.

INTRODUCTION

Trilobites of the *Ehmaniella* Biozone are widespread in the Great Basin and have been extensively

used for the correlation of Middle Cambrian strata both among mountain ranges within this region (Robison, 1964b, 1976; Palmer, 1971a; Kepper, 1972, 1976; Hintze and Robison, 1975) and with other regions in the United States and Canada (Robison, 1964b; Palmer, 1971b). Despite the biostratigraphic importance of this trilobite assemblage, no taxonomic study of this fauna from the Great Basin has been published. Assemblages from the *Ehmaniella* Biozone are known from Arizona (Resser, 1945), Montana (Deiss, 1938), British Columbia (Rasetti, 1951), Tennessee (Resser, 1938a; Sundberg, 1989a), Alabama (Schwimmer, 1989), and Greenland (Poulsen, 1927), but none of the species from these assemblages have been reported from the Great Basin. This paper describes the corynexochid and ptychopariid assemblages of the *Ehmaniella* Biozone from six stratigraphic sections in the central Great Basin, west-central Utah and east-central Nevada (Fig. 1). In addition, the *Ehmaniella* Biozone is subdivided into four local subzones, the *Proehmaniella*, *Elrathiella*, *Ehmaniella*, and *Altiocculus* subzones, and is correlated to other regions within North America.

An important evolutionary aspect of the trilobite faunas of the *Ehmaniella* Biozone is their occurrence at the bottom of the Marjumiid biomere. The lower boundary of the *Ehmaniella* Biozone is an extinction event that marks the end of the corynexochid-dominated Corynexochid biomere

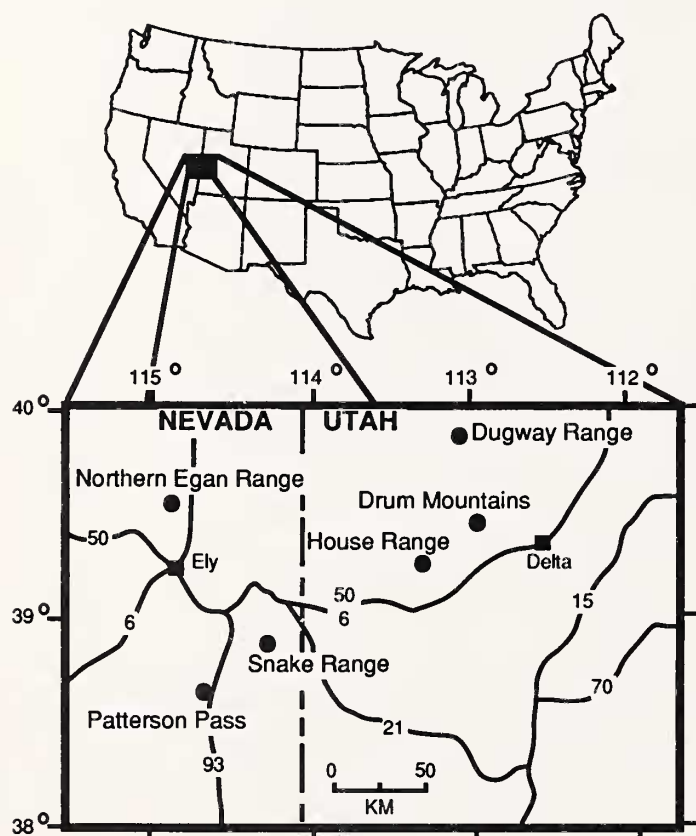


Figure 1. Index map showing location of measured sections.

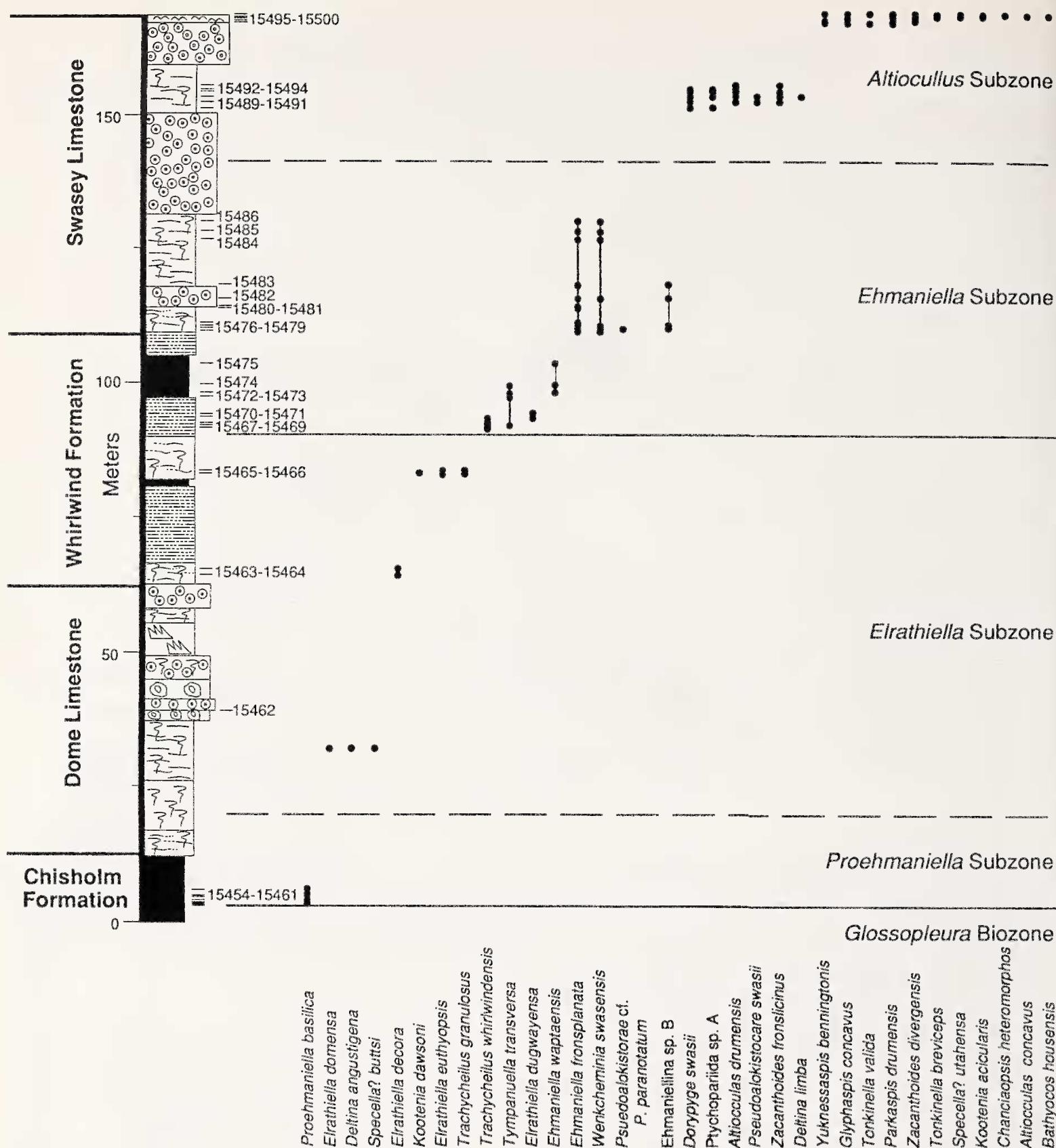


Figure 3. Species range chart for the Drum Mountain section. (See Fig. 79 for lithologic symbols.)

from corynexochid- to ptychopariid-dominated assemblages in the Cambrian and the initial evolution of ptychopariids in the Marjumiid biomere.

STRATIGRAPHY AND DEPOSITIONAL SETTING

The taxa described in this paper are from: the upper Chisholm Formation, Dome Limestone, Whirlwind Formation, Swasey Limestone, and lowermost Wheeler Shale in the Drum Mountains and House Range, Utah; the Upper Shadscale Formation and lower Trailer Limestone in the Dugway Range, Utah; Pole Canyon Formation, Members C through E in

the Snake Range and Patterson Pass area, Nevada; and the middle and upper portions of the Eldorado Limestone in the northern Egan Range (Fig. 1). Section descriptions and locations are given in the Appendix. Lithostratigraphic and chronostratigraphic correlations can be found in Sundberg (1991).

These formations were deposited primarily within an intracratonic basin adjacent to a large-scale carbonate bank. The shale formations, members, and interbeds represent the more basinward deposits, whereas the carbonate units represent the deposits of massive carbonate shoals. The uppermost portion of each section represents the outer, oceanward side of the carbonate shoal or a deep shelf to basal setting (Sundberg, 1991).

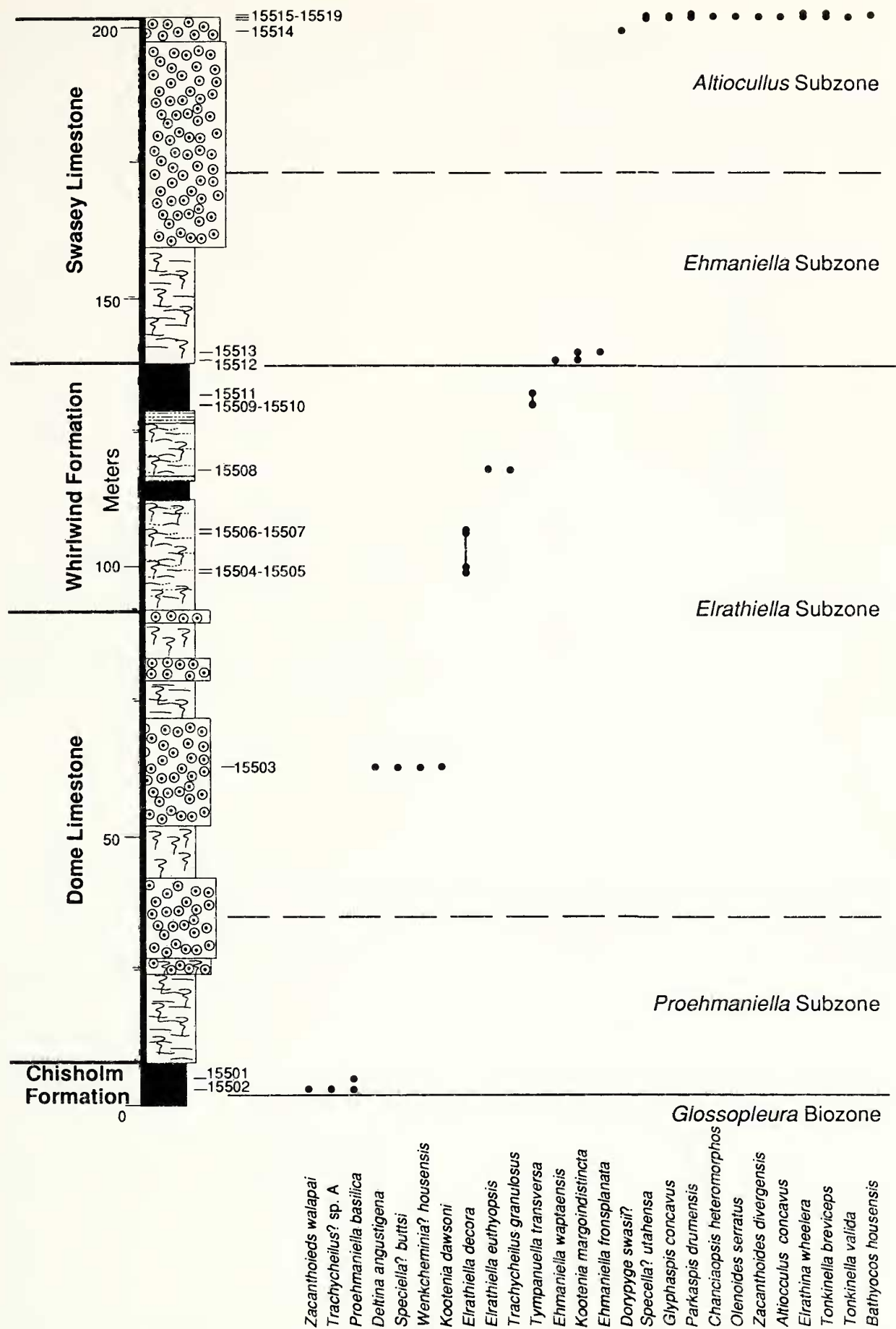


Figure 4. Species range chart for the House Range section. (See Fig. 79 for lithologic symbols.)

BIOSTRATIGRAPHY

The *Ehmaniella* Biozone is considered here as an assemblage zone that occurs between the *Glossopleura* and *Bolaspidea* biozones (Middle Cambrian). Schwimmer (1975) first defined the *Ehmaniella* Biozone as a low-diversity assemblage overlying the *Glossopleura* Biozone and overlain by (in ascending order): *Bolaspis*-*Glyphaspis*, *Ehmania*, *Parehmania* (=Rowia), and *Bolaspidea* biozones.

Robison's (1976) concept of the *Ehmaniella* Biozone encompasses the *Ehmaniella*, *Bolaspis*-*Glyphaspis*, *Ehmania*, and *Parehmania* biozones of Schwimmer (1975). Robison's expanded concept of the biozone is used here. The lower boundary of the *Ehmaniella* Biozone is defined as the first occurrence of *Proehmaniella*, new genus. Robison (1976) defined the lower boundary of the *Ehmaniella* Biozone at the first occurrence of *Ehmaniella* Resser, 1937. However, in the stratigraphic sections

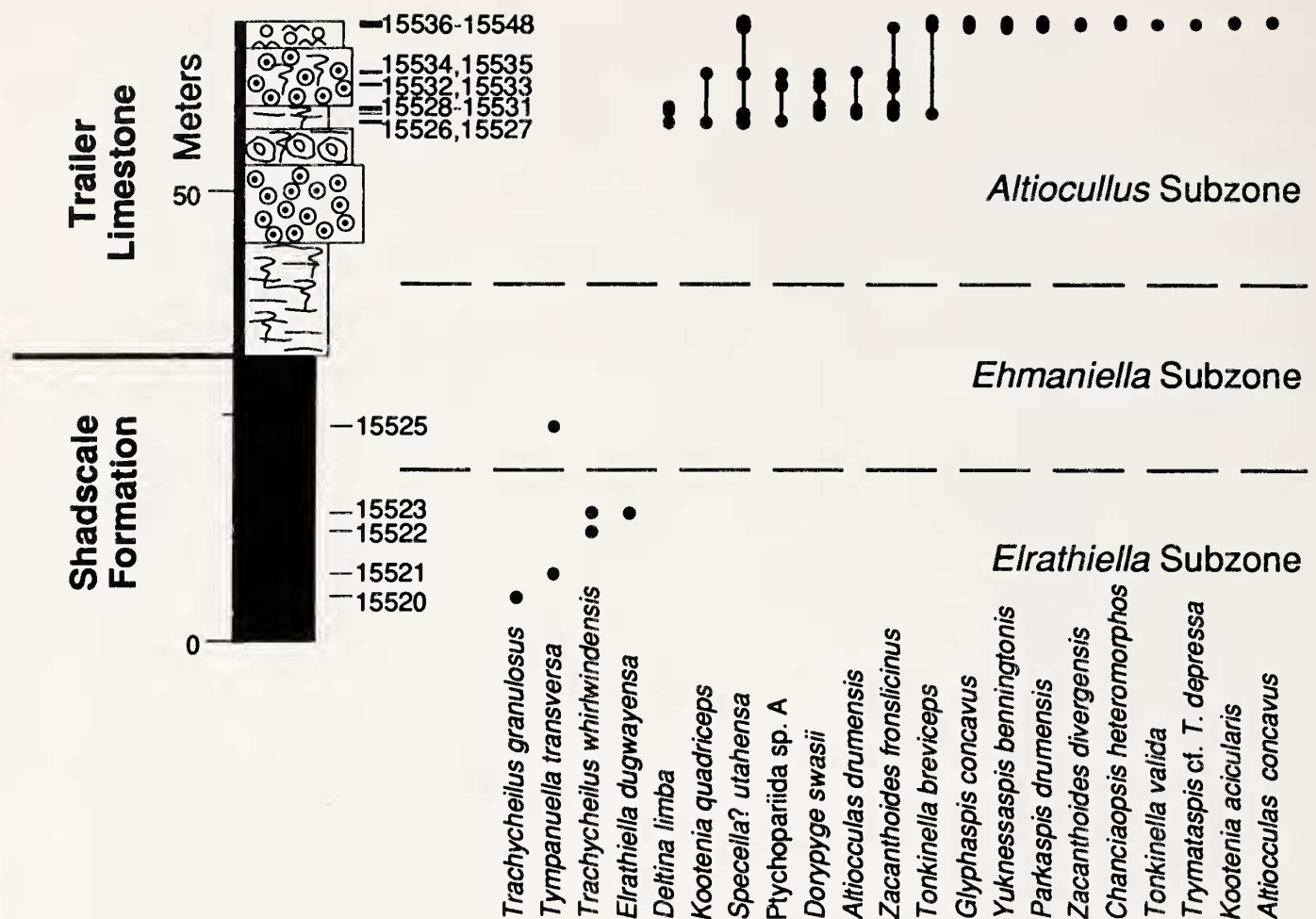


Figure 5. Species range chart for the Dugway Range section. (See Fig. 79 for lithologic symbols.)

studied from the Great Basin, *Ehmaniella* is recognized only from the upper half of the interval that is normally referred to as the *Ehmaniella* Biozone. Taxa previously referred to *Ehmaniella* in the lower half of the biozone (Resser, 1945; Oldroyd, 1973; Campbell, 1974; Hintze and Robison, 1975; Robison, 1976) are either *Elrathiella* Poulsen, 1927, or *Proehmaniella*. *Ehmaniella waptaensis* Rasetti, 1951, is the lowest-occurring species of the genus. This species occurs approximately 35 m above the *Glossopleura* Biozone in the deep-water Stephen Formation, British Columbia (Fritz, 1971), and approximately 95 m above the *Glossopleura* Biozone in the shallow-water Whirlwind Formation, Utah. These stratigraphic positions indicate that *Ehmaniella* does not extend down to the top of the *Glossopleura* Biozone and that it may be limited to only the upper portion of the *Ehmaniella* Biozone. The base of the *Ehmaniella* Biozone has not been raised to the lowest occurrence of the genus, because further analysis of additional sections covering a broader geographic area and spectrum of depositional environments is needed to confirm the limited stratigraphic occurrence of *Ehmaniella* prior to changing the biozonal boundary.

Genera common at various levels in the *Ehmaniella* Biozone of the study area are: *Altiocullus*, new genus; *Dorypyge* Dames, 1883; *Ehmaniella*; *Elrathia* Walcott, 1924; *Elrathiella*; *Kootenia* Walcott, 1889; *Glyphaspis* Poulsen, 1927; *Pagetia* Walcott, 1916; *Parkaspis* Rasetti, 1951; *Peronopsis* Hawle and Corda, 1847; *Proehmaniella*; *Ptychagnostus*

Jaekel, 1909; *Spencella* Rasetti, 1963; *Tonkinella* Mansuy, 1916; *Trachycheilus* Resser, 1945; *Tympanuella*, new genus; *Wenkchemnia* Rasetti, 1951; and *Zacanthoides* Walcott, 1888 (Oldroyd, 1973; Randolph, 1973; White, 1973; Robison, 1982; Korpaska-Merkel, 1983; this study). Based on the first occurrences of key genera, the *Ehmaniella* Biozone is divided into four local subzones, which are (in ascending order): *Proehmaniella*, *Elrathiella*, *Ehmaniella*, and *Altiocullus* subzones. Each subzone is named for its diagnostic genus and is discussed below. The composite stratigraphic ranges of the taxa described in this paper are shown in Figure 2. The taxa ranges within the six stratigraphic sections are shown in Figures 3–8.

The *Ehmaniella* Biozone correlates to the *Bathyriscus*–*Elrathina* Biozone defined by Rasetti (1951). Robison (1976) stated that both *Bathyriscus* Rasetti, 1948, and *Elrathina* Resser, 1937, are not restricted to the biozone, and he suggested the abandonment of Rasetti's biozonal name. In turn, Robison proposed the use of the *Ehmaniella* Biozone for intracratonic-basin deposits and the *Oryctocephalus* Biozone for open-ocean deposits. The *Oryctocephalus* Biozone spans a large stratigraphic interval that is equal to most of the Middle Cambrian including the *Plagiura*–*Poliella*, *Albertella*, *Glossopleura*, and *Ehmaniella* biozones (Robison, 1976). However, *Glossopleura* Poulsen, 1927, and *Ehmaniella* are also known from open-ocean deposits (Resser, 1938a; Rasetti, 1951; Fritz, 1971; Palmer, 1971a; Campbell, 1974; Briggs and Collins,

1988), indicating that the *Glossopleura* and *Ehmaniella* biozones can also be recognized in open-ocean deposits.

The *Ehmaniella* Biozone and its subzones correlate with the *Bathyriscus*–*Elrathina* Biozone and its faunules from the Stephen Formation (Fig. 9). Fritz (1971) recognized five faunules, which are (in ascending order): *Kootenia* sp. 1, *Ogygopsis klotzi*, *Pagetia bootes*, *Ehmaniella burgessensis*, and *Bathyriscus adaeus* faunules. The correlation of the *Proehmaniella* and *Elrathiella* subzones with the *Kootenia* sp. 1 and *Ogygopsis klotzi* faunules is based on their stratigraphic position between the *Glossopleura* Biozone and the first occurrence of *Ehmaniella*. Other than their general assignment to the *Ehmaniella* Biozone, these two subzones and two faunules do not have common taxa that can be used for correlation. The correlation of the *Ehmaniella* and *Altiocullus* subzones with the *Pagetia bootes*, *Ehmaniella burgessensis*, and *Bathyriscus adaeus* faunules is discussed below.

The correlation of the lower three subzones of the *Ehmaniella* Biozone in the study area, the *Proehmaniella*, *Elrathiella*, and *Ehmaniella* subzones, with the *Ehmaniella* to lower *Bolaspis*–*Glyphaspis* biozones of Schwimmer (1973, 1975) from Montana (Fig. 9) is based also on the stratigraphic position of the subzones and Schwimmer’s biozone between the *Glossopleura* Biozone and the first occurrences of *Altiocullus*, *Peronopsis intermedius* (Tullberg, 1880), and *Peronopsis gaspensis* Rasetti, 1948. Schwimmer (1973, 1975) recognized the occurrence of *Ehmaniella* specimens slightly above the *Glossopleura* Biozone in his Montana sections. However, these specimens resemble *Elrathiella* and not *Ehmaniella*. As a result, Schwimmer’s *Ehmaniella* Biozone correlates to a portion of the *Elrathiella* Subzone in the study area. Other than the genus *Elrathiella*, the three subzones in the study area and the faunas of the *Ehmaniella* to lower *Bolaspis*–*Glyphaspis* biozones in Montana have no taxa in common that are used for correlation. The correlation with the *Altiocullus* Subzone to the upper *Bolaspis*–*Glyphaspis*, *Ehmania*, and *Parehmania* Biozones is discussed below.

PROEHMANIELLA SUBZONE

This subzone is the lowermost subzone of the *Ehmaniella* Biozone. The lower boundary is defined by the first occurrence of *Proehmaniella*, which is well constrained with several fossil collections bracketing the boundary (Fig. 2) in four of the Great Basin sections. Common species in this subzone are *Proehmaniella basilica* (Resser, 1945); *Zacanthoides walapai* Resser, 1945; *Wenkchemnia?* *housensis*, new species; and *Kootenia dawsoni* (Walcott, 1889). Only one species from the underlying *Glossopleura* Biozone ranges into this subzone; *Glossopleura boccar* (Walcott, 1916) occurs in the lower 10 cm of the *Proehmaniella* Subzone in the Drum Mountains (Sundberg, 1990).

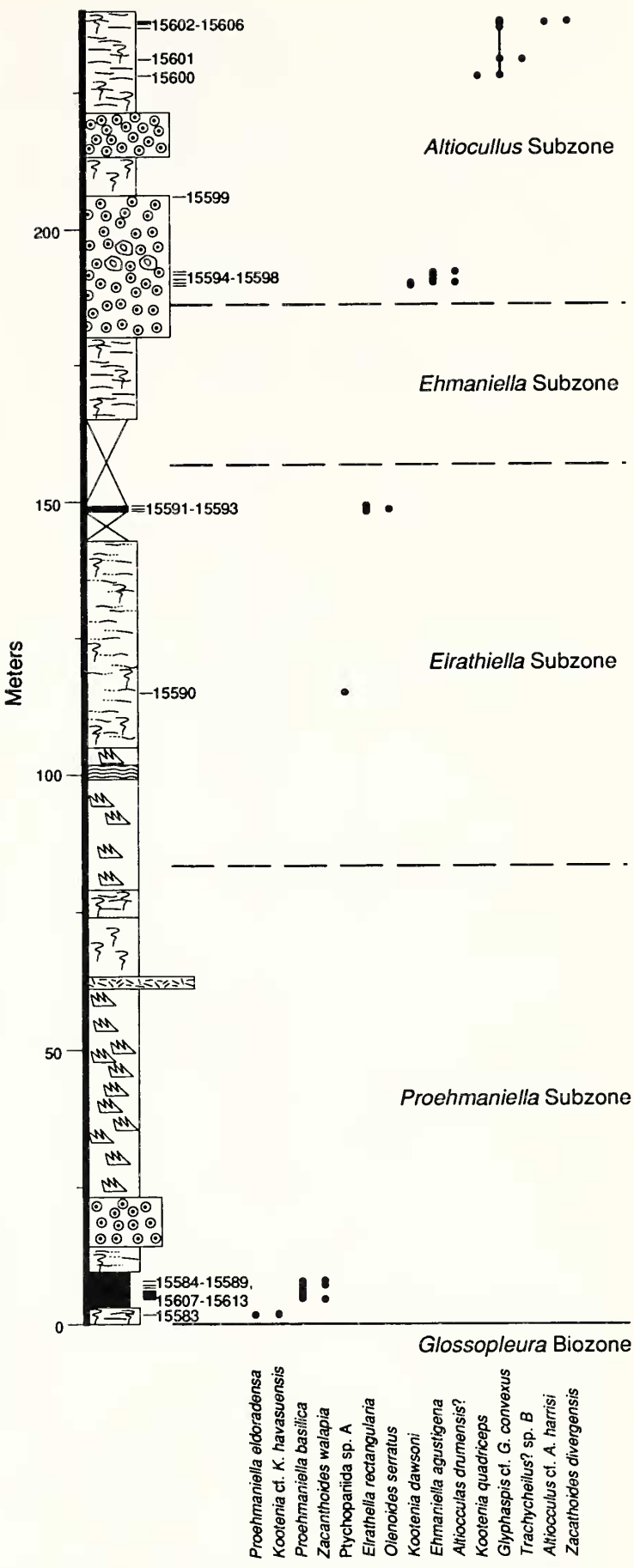


Figure 6. Species range chart for the northern Egan Range section. (See Fig. 79 for lithologic symbols.)

ELRATHIELLA SUBZONE

This subzone occurs above the *Proehmaniella* Subzone. The lower boundary is defined by the first occurrence of *Elrathiella*, which is poorly constrained since only a few fossil collections are located near the boundary in the studied sections (Fig. 2). Common species in this subzone are *Elrathiella decora* Resser, 1945; *Elrathiella dugwayensa*, new species; *Trachycheilus granulatus*, new species;

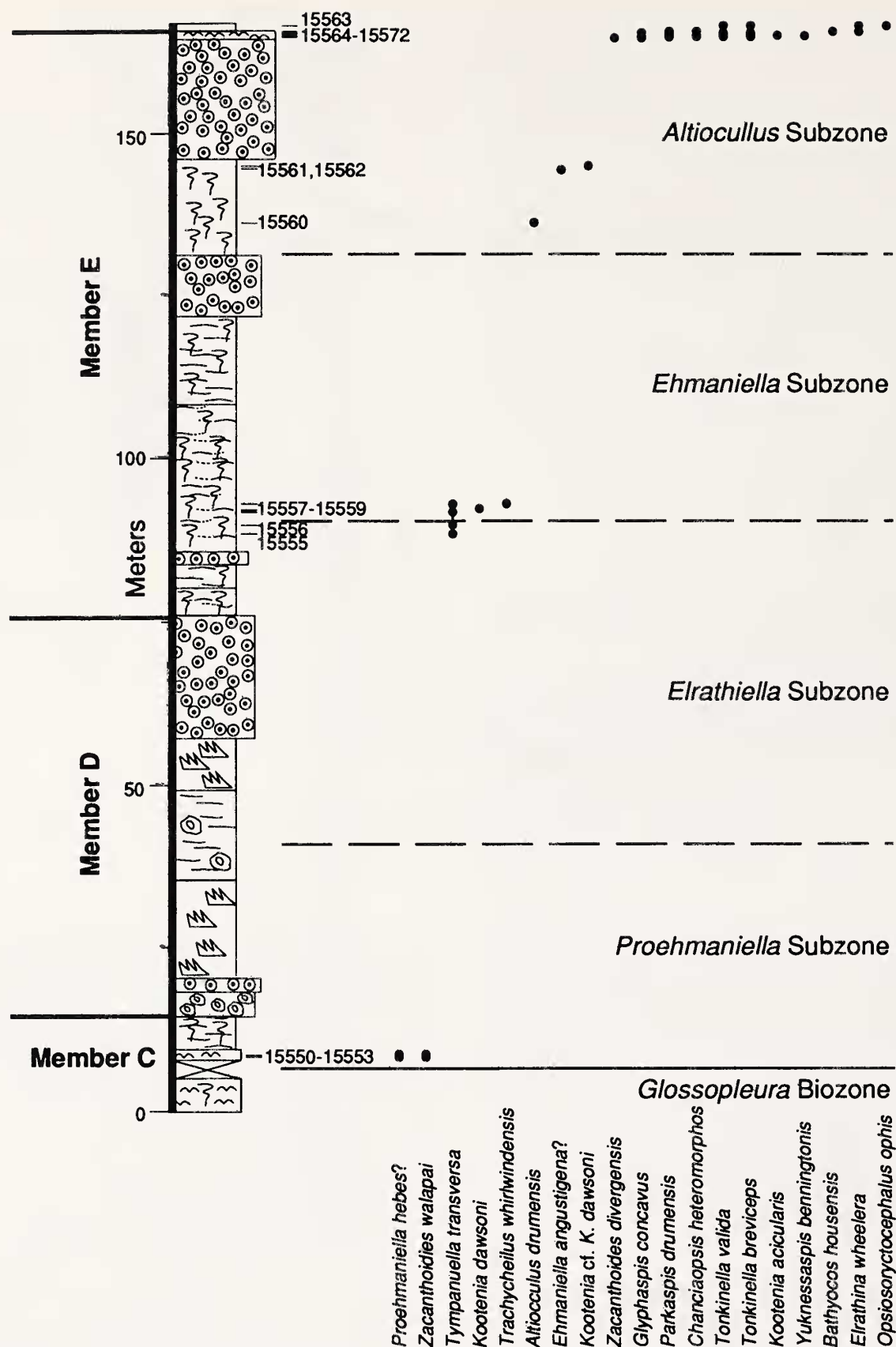


Figure 7. Species range chart for the Snake Range section. (See Fig. 79 for lithologic symbols.)

Trachycheilus whirlwindensis, new species; and *Tympanuella transversa*, new species.

EHMANIELLA SUBZONE

This subzone occurs above the *Elrathiella* Subzone. The lower boundary is defined by the first occurrence of *Ehmaniella*, which is well constrained with several fossil collections bracketing the boundary (Fig. 2). Common species in this subzone are *Ehmaniella waptaensis*, *Ehmaniella fronsplanata*, new species, *Wenkchemnia swasensis*, new species, and *Tympanuella transversa*.

The *Ehmaniella* Subzone correlates to the upper

Ogygopsis klotzi, *Pagetia bootes*, and *Ehmaniella burgessensis* faunules of Fritz (1971; Fig. 9). The stratigraphic position of *Ehmaniella waptaensis* in both regions provides the correlation of the subzone to the three faunules. It is not known how much of the *E. burgessensis* faunule correlates to either the *Ehmaniella* Subzone or the overlying *Altiocullus* Subzone because the boundary between the two subzones is poorly constrained and because of the low diversity of the *E. burgessensis* faunule (Rasetti, 1951; Fritz, 1971).

In the Stephen Formation, *Ehmaniella waptaensis* occurs with *Ptychagnostus praecurrens* (Westergård, 1936) (= *Ptychagnostus burgessensis* [Ra-

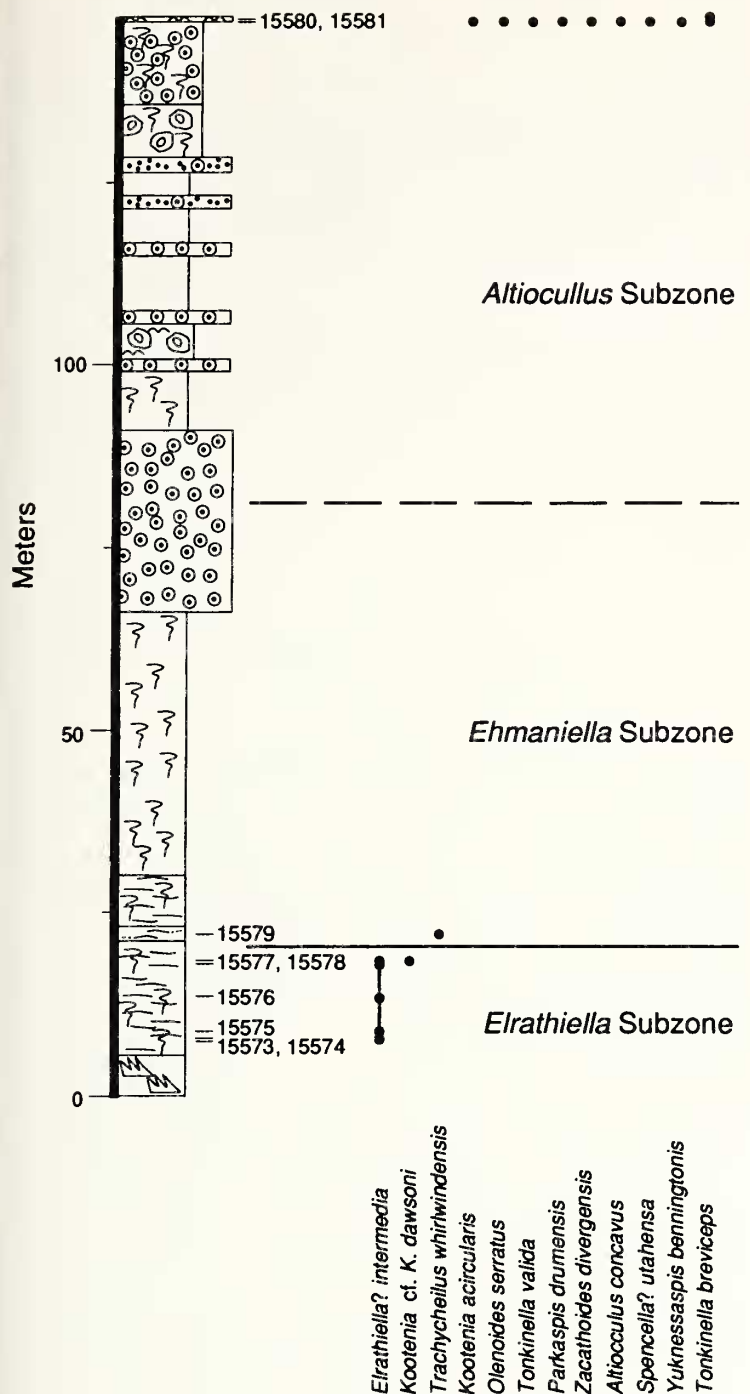


Figure 8. Species range chart for the Patterson Pass section. (See Fig. 79 for lithologic symbols.)

setti, 1951] of Fritz [1971]; Robison [1982, 1984]). This indicates that the *Ehmaniella* Subzone correlates to part of the *Ptychagnostus praecurrens* Biozone (Fig. 9).

ALTIOCULLUS SUBZONE

This subzone occurs above the *Ehmaniella* Subzone and is the uppermost subzone in the *Ehmaniella* Biozone. The lower boundary is defined by the first occurrence of *Altiocullus*, which is poorly constrained because fossil collections containing assemblages diagnostic of either of the two subzones are separated by a relatively thick, unfossiliferous interval of the Swasey Limestone (Fig. 2). The upper boundary of the *Altiocullus* Subzone is defined by the first occurrence of *Bolaspidea* Resser, 1937, which marks the lower boundary of the *Bolaspidea* Biozone. In the sections studied, the common species in this subzone are *Altiocullus drumensis*,

This Paper	Agnostoid Robison, 1982, 1984	Schwimmer, 1973, 1975	Fritz, 1971	Young and Ludvigsen, 1989
<i>Bolaspidea</i>	<i>P. atavus</i>	<i>Bolaspidea</i>		Zone 3
<i>Altiocullus</i>	<i>P. gibbus</i>	<i>Parehmania</i>	<i>Bathyriscus</i> <i>adaeus</i> Faunule	Zone 2
		<i>Ehmania</i>	<i>Ehmaniella</i> <i>burgessensis</i> Faunule	<i>Zacanthoides</i> <i>gilbeti</i> Fauna
		<i>Bolaspis- Glyphaspis</i>		
<i>Ehmaniella</i>	<i>P. praecurrens</i>	?	<i>Pagetia</i> <i>bootes</i> Faunule	
		<i>Ehmaniella</i>	<i>Ogygopsis</i> <i>klotzi</i> Faunule	
<i>Elrathiella</i>			<i>Kootenia</i> sp. 1 Faunule	
<i>Proehmaniella</i>				
<i>Glossopleura</i>		<i>Glossopleura</i>	<i>Glossopleura</i>	

Figure 9. Correlation chart of polymeroid biostratigraphic units from the study area to agnostid and other polymeroid sequences.

new species, *Altiocullus concavus*, new species, *Dorypyge swasii*, new species, *Glyphaspis concavus*, new species, *Parkaspis drumensis*, new species, *Peronopsis* cf. *P. fallax* (Linnarsson, 1869), and *Tonkinella breviceps* Kobayashi, 1934. In the Wheeler Shale, the trilobite faunas are dominated by the agnostoids *Peronopsis amplexis* Robison, 1982, *Ptychagnostus gibbus* (Linnarsson, 1869), and *Ptychagnostus intermedius* (see Robison, 1982; Rowell et al., 1982). As defined here, the *Altiocullus* Subzone also incorporates the upper part of the *Ptychagnostus praecurrens* agnostoid biozone and the majority of the *P. gibbus* agnostoid biozone (Fig. 9).

The *Glyphaspis* fauna of Hintze and Robison (1975) and Rees (1986) is equivalent to the faunas of the *Altiocullus* Subzone in the uppermost portion of the Swasey Limestone. Robison (1964b) correlated the *Parkaspis endecamera* faunule of Rasetti (1951) from British Columbia to the faunas in the uppermost portion of the Swasey Limestone. The strong similarity between the two faunas is shown by the occurrence of similar or identical species of the genera *Altiocullus*; *Glyphaspis*; *Parkaspis*; *Peronopsis*; *Tonkinella*; *Yuknessaspis* Rasetti, 1951; and *Zacanthoides* in both assemblages.

[illegible]

Figure 10. Correlation chart of formations within the study area and other regions of North America. Dots indicate paleontological control; question marks indicate questionable correlation. Data for outside the study area from Resser (1945), Palmer (1971a), Fritz (1971), Schwimmer (1973, 1975), Hintze and Robison (1975), Robison (1982, 1984), and Sundberg (1989a).

The fauna in the *Altiocculus* Subzone of the uppermost Swasey is also similar to the *Tonkinella stephensis* and *Bathyriscus adaeus* faunules of Rasetti (1951) and/or Fritz (1971), with the occurrence of similar or identical species of the genera *Altiocculus*; *Chanciaopsis*, new genus; *Elrathina*; *Pagetia*; *Peronopsis*; *Spencella*; *Tonkinella*; and *Zacanthoides*.

The upper portion of the *Bolaspis*–*Glyphaspis* Biozone of Schwimmer (1973, 1975) correlates to the lower portion of the *Altiocculus* Subzone (Fig. 9) based on the occurrence of *Kootenia quadriceps* (Hall and Whitfield, 1877), *Tonkinella*, *Glyphaspis*, and *Spencella* and stratigraphic position of the *Bolaspis*–*Glyphaspis* Biozone below the *Ehmania* Biozone. The upper portion of the *Ehmania* Biozone contains *Peronopsis intermedius*, *Peronopsis gaspensis*, and *Peronopsis montis* (Matthew, 1899) of the lower *Ptychagnostus gibbus* Biozone (Schwimmer, 1973, 1975; Robison, 1982) and correlates to the middle portions of the *Altiocculus* Subzone. The lower portion of the *Parehmania* Biozone (Schwimmer, 1975) also contains *Peronopsis intermedius*, *Peronopsis gaspensis*, and *Peronopsis montis* of the lower *Ptychagnostus gibbus* Biozone (Schwimmer, 1973, 1975; Robison, 1982) and correlates to the upper portion of the *Altiocculus* Subzone.

The *Zacanthoides gilberti* fauna of Young and Ludvigsen (1989) and Zone 2 of Kindle (1982; Young and Ludvigsen, 1989) are equivalent to the *Altiocculus* Subzone of the Great Basin (Fig. 9). This correlation is based on the occurrence of *Tonkinella breviceps*; *Tonkinella valida* Tchernysheva, 1962; *Peronopsis fallax*; *Ptychagnostus gibbus*; and *Peronopsis interstricta* (White, 1874) and similar species of *Parkaspis*, *Chanciaopsis*?, and *Elrathina* in both assemblages.

CHRONOSTRATIGRAPHIC CORRELATIONS

The identification of the lower boundary of the *Ehmaniella* Biozone and the four subzones in the study area provides for the detailed chronostratigraphic correlation of the lithostratigraphic units in the Great Basin. Figure 10 presents these correlations within the study region and with other sections within North America.

The lower boundary of the *Ehmaniella* Biozone represents a major faunal turnover in Cambrian trilobites and is the lower boundary of the Marjumiid bioterm (Sundberg, 1990). The faunal boundary between the *Glossopleura* Biozone and *Proehmaniella* Subzone has been accurately located in the lower 5 m of the upper shale member of the Chisholm Formation in the Drum Mountains (Fig. 3) and in the upper 5 m of the same unit in the House Range (Fig. 4). The same boundary occurs in the upper portion of Member C of the Pole Canyon Limestone in the Snake Range (Fig. 7). However, in the Patterson Pass area, Member C contains only

Glossopleura Biozone faunas. This boundary also occurs 2 m above the base of a shale member of the Eldorado Formation, approximately 240 m below the upper contact of the formation in the northern Egan Range (Fig. 6).

The faunal change from the *Glossopleura* Biozone to *Proehmaniella* Subzone assemblages is also present in the middle to upper Bright Angel Shale in the Grand Canyon (Resser, 1945) and lowermost Ute Formation of Utah (Campbell, 1974). Several other sections in western North America also contain the boundary between the *Glossopleura* and *Ehmaniella* biozones. The *Proehmaniella* Subzone is not known to be present in these sections, due either to the absence of the fauna or to the lack of a detailed study. The biozonal boundary occurs within the lower 20 m of the Ute Formation in Antimony Canyon, Utah (Palmer, 1971a), lower 200 m of the Abercrombie in the Deep Creek Range, Utah (Palmer 1971a), lower 70 m of the Wolsey Shale of southern Montana (Schwimmer, 1973), lower 20 m of the Dearborn Limestone of northwest Montana (Schwimmer, 1973), and within the boundary limestone of the Stephen Formation of British Columbia (Fritz, 1971). In the eastern United States, this biozonal boundary occurs within the lower 12 m of the Rogersville Shale of the Conasauga Group, Tennessee (Sundberg, 1989a).

The faunas of the *Elrathiella* Subzone occur in five of the sections within the study area and also in the Grand Canyon. The apparently limited distribution of this subzone outside of the study area probably results from specimens of *Elrathiella* being referred to *Ehmaniella*. The *Elrathiella* Subzone occurs in the upper Dome Limestone and throughout most of the Whirlwind Formation in the Drum Mountains and House Range (Figs. 3 and 4). Faunas of this subzone occur in the lower half of Member E of the Pole Canyon Limestone in the Snake Range and Patterson Pass sections and in the upper portion of the Shadscale Formation of the Dugway Range (Figs. 5, 7, and 8). In the Grand Canyon, *Elrathiella decora* occurred in a float block (Resser, 1945) possibly derived from the Muav Limestone. *Elrathiella decora* occurs in the lowermost portion of the Whirlwind Formation in the study area. Schwimmer (1973) stated that species of *Elrathiella* reported by Deiss (1939) from Montana are incorrectly assigned to the genus. However, specimens assigned to *Ehmaniella* by Schwimmer (1973) from the Meagher Limestone and Wolsey Shale are *Elrathiella*, indicating the possible presence of the *Elrathiella* Subzone in Montana.

The faunas of the *Ehmaniella* Subzone occur in three of the sections within the study area. This subzone occurs in the uppermost Whirlwind Formation and lower portion of the Swasey Limestone in the Drum Mountains and House Range (Figs. 3 and 4). Faunas of this subzone also occur in the lower portion of Member E of the Pole Canyon Limestone in the Patterson Pass section (Fig. 8). The widespread occurrence of *Ehmaniella*

throughout the Great Basin reported by Palmer (1971a) and Hintze and Robison (1975) may represent the occurrence of the similar genus *Elrathia*. As a result, the chronostratigraphic correlation of the units reported as containing *Ehmaniella* must be used with caution. The *Ehmaniella* Subzone can be recognized in the Burgess Shale of the Stephen Formation, as discussed above.

The faunas of the lower portion of the *Altioculus* Subzone (faunas below the *Ptychagnostus gibbus* Biozone) are widespread in North America. In the sections studied, the fauna can be divided into two assemblages, the *Dorypyge*-*Altioculus* assemblage and the *Glyphaspis*-*Parkaspis* assemblage (= *Glyphaspis* Fauna of Hintze and Robison, 1975; Sundberg, 1991). These two assemblages and the faunas of the overlying *Ptychagnostus gibbus* Biozone are environmentally controlled (Sundberg, 1991) and probably diachronous. The *Dorypyge*-*Altioculus* assemblage is a low-diversity assemblage that occurs in pelmetazoan-trilobite grainstones. The *Glyphaspis*-*Parkaspis* assemblage is a higher-diversity assemblage that contains *Pagetia*, *Peronopsis*, and *Elrathia* and occurs in trilobite packstones to grainstones. This latter assemblage is the more open-ocean, deeper-water fauna of the two assemblages (Sundberg, 1991). The overlying faunas of the *P. gibbus* Biozone are deep-water assemblages (Robison, 1976). As a result, the chronostratigraphic correlation of stratigraphic units containing these faunas is inaccurate to a degree because of the unknown rate of environmental change within the region. The *Dorypyge*-*Altioculus* assemblage is recognized in three sections in the study area. The assemblage occurs in the upper Swasey Limestone in the Drum Mountains, upper portion of the middle Trailer Limestone in the Dugway Range, and in the upper portion of the upper limestone member of the Eldorado Formation in the northern Egan Range. This assemblage is not presently recognized outside of the study area. The *Glyphaspis*-*Parkaspis* assemblage is widespread, occurring in the uppermost portion of the Swasey Limestone in the Drum Mountains and House Range, Member E of the Pole Canyon Limestone in the Snake Range and Patterson Pass section, lower member of the Trailer Limestone of the Dugway Range, the upper limestone member of the Eldorado Formation of the northern Egan Range, and several other sections in the Great Basin (see Hintze and Robison, 1975). This assemblage also occurs in the uppermost Stephen Formation and Eldon Formation of British Columbia (Rasetti, 1951; Fritz, 1971) and in boulders from Newfoundland (Young and Ludvigsen, 1989). Similar faunas occur in the upper Dearborn Limestone and lower Pagoda Limestone in northwest Montana and in the upper Wolsey Shale and lower Meagher Limestone of south-central Montana (Schwimmer, 1973, 1975).

Hintze and Robison (1975) and Robison (1976, 1982, 1984) discussed the stratigraphic and geographic distributions of the faunas of the *Ptycha-*

agnostus gibbus Biozone. Figure 10 uses their information.

SYSTEMATIC PALEONTOLOGY

Corynexochida and Ptychopariida specimens belonging to 24 genera and 55 species are reported from the *Ehmaniella* Biozone in the Drum Mountains, House Range, Dugway Range, northern Egan Range, Patterson Pass, and Snake Range sections. Supergeneric classification of the corynexochids used here is that of Moore (in Harrington et al., 1959).

The familial classification of ptychopariids used here is not based on Harrington et al. (1959). Their Lower to Middle Cambrian ptychopariid trilobite groups are probably polyphyletic. For example, Alokistocaridae Resser, 1939a, contains a variety of taxa possessing generalized morphologies. To date, only two genera have been removed from this assemblage; *Dunderbergia* Walcott, 1924, was placed in the Elviniidae Kobayashi, 1935 (Palmer, 1965), and *Perioura* Resser, 1938a, was equated to *Modocia* Walcott, 1924 (Robison, 1964a), and thus belongs in the Marjumiidae Kobayashi, 1935. This study shows that *Ehmaniella* and other similar genera in the *Ehmaniella* Biozone formerly grouped in the Alokistocaridae are closely related and form a distinct clade here termed Ehmaniellidae.

Supergeneric classification of Cambrian ptychopariids in Harrington et al. (1959) is based primarily on cranial characters. However, Palmer (1965) used the combination of morphologic similarity of genera and their close stratigraphic relationship to demonstrate the close phylogenetic relationship of genera previously assigned to several different families. Palmer's (1965) reclassification of these genera suggested that general morphological types of cranidia were redeveloped during the Cambrian and that these morphological types should not be used solely as the basis to determine phylogenetic relationships among genera. The morphometric study presented by Sundberg (1989b, 1990) further illustrated that cranial character states were being redeveloped within each biomere. These studies suggest that there was considerable convergence in trilobite morphologies in the Cambrian. Palmer (1965) used the combination of morphological similarity of genera and their stratigraphic relationship to develop his supergeneric taxonomy in the Pteropcephaliid Biomere. He removed several genera from previously established families and placed them in essentially new families (although old family names were used). The supergeneric classification of the Ptychopariida used here is based on the style of systematics used by Palmer (1965), where both morphologic similarity and stratigraphic relationship are important aspects in the classification scheme.

SPECIES AND SUBSPECIES

The concept of geographically separated demes that are distinct in some morphological aspect was help-

ful in determining the taxonomic level to be used for the trilobite specimens from the *Ehmaniella* Biozone. If a modern species consists of several geographically separated demes that have low gene flow among them, then some morphologic characters of a deme may be distinct from other demes. This difference may result from the founders effect (Mayr, 1954) where a geographic area is first settled by a limited number of organisms. These organisms could have a limited range of genetic variation available in the entire population of the species. If gene flow between an isolated deme and the remaining portion of the species' population is limited, then a morphological character can become fixed in that deme (Mayr, 1982). An example of modern, isolated demes where morphological characters have become fixed has been documented for birds by Mayr (1954; Mayr and Vaurie, 1948). Each of these morphologically distinct demes is referred to as a subspecies.

In the geologic record, isolated demes of a species would be represented as geographically and probably temporally distinct fossil populations possessing similar morphologies but differing in some character state. In the *Ehmaniella* Biozone and the underlying *Glossopleura* Biozone, there are collections of specimens of several species that match the morphological, geographical, and temporal pattern expected from the preservation of isolated demes. In these examples, the specimens from all of the collections of a species are morphologically similar; however, a collection from an individual locality contains specimens that possess a character state that is unlike character states of specimens from the other localities. Such collections differ in either their geographic location, stratigraphic position, or both. For example, in the Corynexochida, *Zacanthoides divergens* Rasetti, 1951, contains three subspecies that all occur at about the same stratigraphic position. In this instance, the subspecies all have very similar cranidia with strongly divergent anterior facial sutures and rectangular pygidia, but they differ in the length of the preglabellar field and the construction of the anterior border. Similar differences have been used by some authors to differentiate species of *Zacanthoides* (e.g., Rasetti, 1951; Young and Ludvigsen, 1989). However, the overall similarity of morphology and age of the specimens suggests that they represent different populations of *Z. divergens* and should be considered subspecies. In the Ptychopariida, *Ehmaniella fronsplanata* contains three subspecies that are found in collections separated from each other by 4 m of lime mudstone. In this case, the subspecies have small, flattened, nearly rectangular cranidia and transversely elongate pygidia, but they differ in the convexity of the anterior border. The oldest subspecies has a distinctly convex anterior border, the medial age subspecies has a distinctly concave anterior border, and the youngest subspecies has a nearly flat anterior border. Similar differences in other Cambrian trilobite taxa have been used to

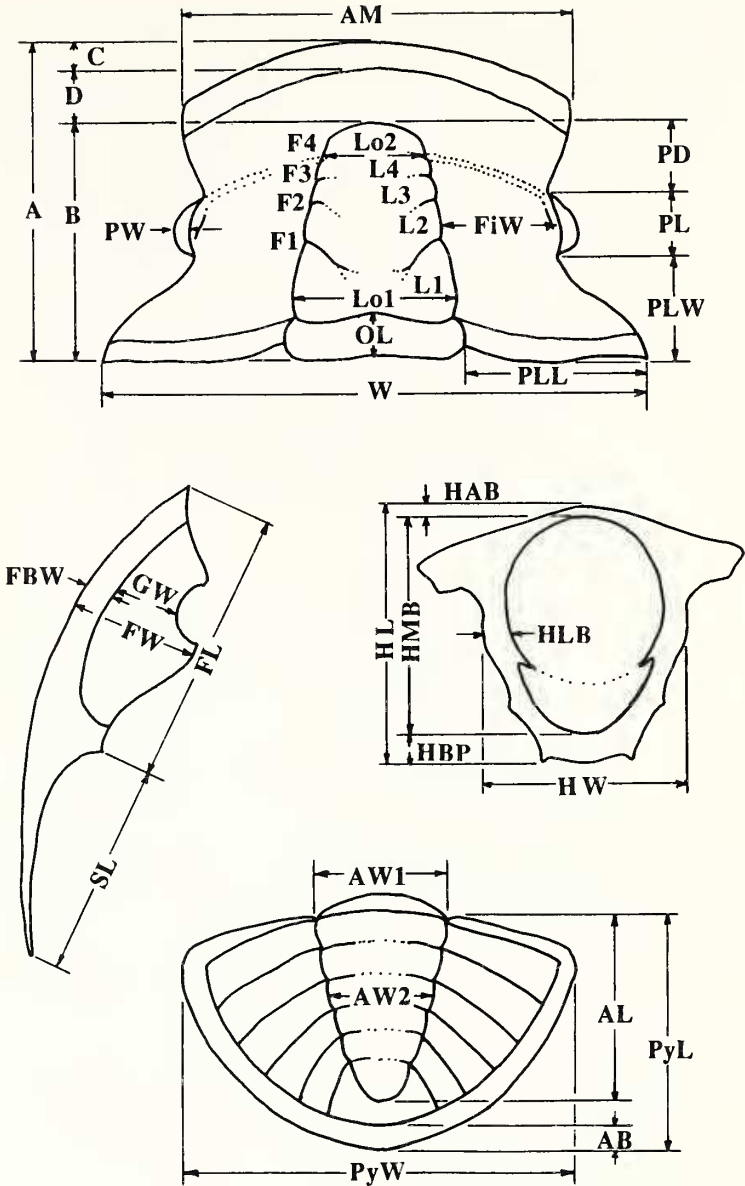


Figure 11. Measurements and abbreviations used. See Table 1 for abbreviation descriptions.

separate species. However, the overall similarity of morphology and close stratigraphic occurrences of the different morphologies of *Ehmaniella fronsplanata* suggests that they are an expression of local demes and are thus classified as subspecies.

MEASUREMENTS, RATIOS, AND TERMINOLOGY

Measurements used in the following descriptions are illustrated in Figure 11 and listed in Table 1. Measurements were taken with a micrometer attached to a binocular microscope. Only five or fewer cranidia, hypostomata, librigenae, or pygidia were typically measured for each species. As the result of the low number of specimens measured, ratios are given as ranges instead of averages and standard deviations. The ratios in most cases were rounded to the nearest 5% (e.g., a morphology that ranges from 37 to 43% is reported as ranging from 35 to 45%). Exceptions occur when only one specimen was measured, when the range of percentages is close to a single 5% value (e.g., 33–37%) and when more detail is required to separate species. In the first two cases, the ratios are listed as an approxi-

Table 1. Measurements of cranial, librigena, hypostoma, and pygidial characters.

A	Cranial length—sagittal length of the cranium from the posterior margin of the occipital ring (excluding occipital spine) to the anterior margin of the cephalon.
AB	Border length—maximum sagittal length of the pygidium border at the posterior margin.
AL	Axis length—maximum sagittal length of the axis exclusive of the postaxial ridge.
AM	Anterior margin width—transverse width from the lateral margins of the anterior border.
AW1	Axis width—maximum width of the axis at the anterior margin of the pygidium.
AW2	Medial axis width—width of the axis half-way from the anterior margin to the termination of the axis.
B	Glabellar length—sagittal length of the glabella from the posterior margin of the occipital ring (excluding occipital spine) to the anterior margin of the frontal glabellar lobe.
C	Anterior border length—sagittal length of the anterior border from the anterior border furrow to the cephalon anterior margin.
D	Preglabellar field length—sagittal length of the prelabellar field from the anterior margin of the frontal glabellar lobe to the anterior border furrow.
F1-F4	Lateral glabellar furrows—posterior to anterior.
FBW	Librigena border width—measured parallel to librigena width.
FiW	Fixigena width—transverse width from the axial furrow to the palpebral lobe furrow.
FL	Librigena length—measured from the junction of the facial suture and anterior margin to the junction of the facial suture and posterior margin.
FW	Librigena width—measured perpendicular to librigena length from below the optic notch to the lateral margin.
GW	Genal field width—measured parallel to librigena width from the optic notch to the lateral border furrow.
HAB	Hypostoma anterior border width—sagittal width from the anterior margin to the median body.
HL	Hypostoma length—sagittal length from the anterior to posterior margins.
HLB	Hypostoma lateral border width—transverse width from the lateral margin to the median body.
HMB	Hypostoma median body length—sagittal length from the anterior to posterior margin of body.
HPB	Hypostoma posterior border width—sagittal width from the posterior margin to the median body.

Table 1. Continued.

HW	Hypostoma width—transverse width between the lateral margins.
L1-L4	Glabellar lobes—posterior to anterior.
Lo1	Glabellar width—maximum transverse width of the preoccipital lobe.
Lo2	Anterior glabellar width—maximum transverse width of the frontal glabellar lobe, measured just below or above the eye ridges.
OL	Occipital ring length—maximum sagittal length of the occipital ring.
PD	Palpebral lobe vertical position—maximum sagittal distance of the anterior tip of the palpebral lobe from the top of the glabella.
PL	Palpebral lobe length—maximum length of the palpebral lobe measured parallel to the sagittal line.
PLL	Posterior area of fixigena length—transverse length from the occipital ring to the posterior limb tip.
PLW	Posterior area of fixigena width—exsagittal width below the palpebral lobe.
PW	Palpebral lobe width—transverse width from the palpebral lobe furrow to the lateral margin.
PyL	Pygidial length—sagittal length of the pygidium exclusive of spines.
PyW	Pygidial width—maximum width of the pygidium exclusive of spines.
SL	Spine length—measured parallel to librigena length from the junction of the facial suture and posterior margin and tip of spine.
W	Cranial width—transverse width from the lateral tips of the posterior limbs.

mate rounded percentage (e.g., approximately 35%). The actual percentages are reported in the third case.

The terminology used is that of Harrington, Moore, and Stubblefield (in Harrington et al., 1959). Terms used to modify some of the morphological characters are listed in Table 2.

Abbreviations used are: KUMIP = Museum of Invertebrate Paleontology, University of Kansas; LACMIP = Invertebrate Paleontology Section, Los Angeles County Museum of Natural History; RC = Richard Robison collection housed at the University of Kansas; USGS = United States Geologic Survey; USNM = United States National Museum; trans. = transverse; sag. = sagittal; and exsag. = exsagittal. Other abbreviations are presented in Table 1.

Phylum Arthropoda
Siebold and Stannius, 1845
Class Trilobita Walch, 1771

Order Corynexochida
Kobayashi, 1935
Family Dorypygidae
Kobayashi, 1935

Genus *Dorypyge* Dames, 1883

TYPE SPECIES. *Dorypyge richthofeni* Dames, 1883.

EMENDED DIAGNOSIS. Dorypygidae with cranidium with medially inflated to subquadrate glabellae, effaced to nearly effaced lateral glabellar furrows; fixigenae convex, slightly downsloping. Pygidium with well-defined axis generally extending to border, 3–5 ring furrows; pleural fields crossed by 3–5 generally deep pleural furrows; interpleural furrows shallow, exsagittal width of anterior pleural bands increases laterally; width of posterior pleural bands uniform; border moderately well defined, generally 3–4 pairs of spines of equal length, a posterior pair of greater length, and most posterior pair very short, unevenly spaced along margin.

REMARKS. The cranidia of *Dorypyge*, *Kootenia*, and *Olenoides* Meek, 1877, are similar in their general appearance. Glabellae tend to be subquadrate to medially expanded (suboval) in several species of *Dorypyge*, whereas in *Kootenia* glabellae expand either anteriorly or medially (see Suvorova, 1964). Glabellae of *Olenoides* expand anteriorly. The pygidia of *Dorypyge* differ from *Kootenia* in having unequal spine lengths, slightly better defined interpleural furrows, and anterior pleural bands that expand laterally in exsagittal width, whereas the posterior pleural bands are uniform in width (Fig. 12; also see the paratype pygidia of Dames [1883] illustrated by Kobayashi [1937] and Schrank [1977] and figured specimens of Resser and Endo [in Endo and Resser, 1937], Lermontova [in Vologdin, 1940], Whitehouse [1945], Palmer [1968], and *D. swasii* [Fig. 13.6]). The expansion of the anterior pleural bands is also present in the pygidia of *Olenoides* (Fig. 12); however, pygidia of *Dorypyge* differ in their shallower pleural and interpleural furrows and generally better defined borders. The pygidial borders in *Dorypyge* range from relatively wide (e.g., *D. swasii*, *D. pergranosa* Resser and Endo, 1937 [in Endo and Resser, 1937]) to relatively narrow (e.g., *D. richthofeni*, *D. ternek* Dean, 1982). In the pygidia with narrower borders, the pleural furrows cross the border and some the pygidial spines may project from the posterior pleural bands.

Dorypyge swasii, new species

Figure 13

Dorypyge, n. sp. Sundberg, 1991:388, figs. 2.13, 2.14.

DIAGNOSIS. *Dorypyge* with pygidium having 5 pairs of spines, anterior 4 pairs of lateral spines increasing in length from anterior to posterior, posterior pair of spines very short, 4 axial rings, border

Table 2. Selected cranidial and pygidial character modifying terminology.

Cranidium	
Size	
Small	0–5 mm
Moderate	5–15 mm
Large	15 mm–larger
Glabellar tapering (percentage of anterior width of glabella to glabellar width)	
Very strongly	55–65
Strongly	65–75
Moderately	75–85
Slightly	85–95
Very slightly	95–100
Expanding	100–greater
Palpebral lobe width (percentage relative to palpebral lobe length)	
Narrow	0–30
Moderate	30–40
Wide	40–greater
Palpebral lobe length (percentage of glabellar length)	
Short	0–30
Moderate	30–40
Long	40–greater
Direction of ocular ridge (degrees relative to axial trend)	
Very strongly posterolateral	45–55
Strongly posterolateral	55–65
Moderately posterolateral	65–75
Slightly posterolateral	75–85
Lateral	85–95
Pygidium	
Size	
Small	0–5 mm
Moderate	5–15 mm
Large	15–larger
Axis tapering (percentage of mid-width to anterior width)	
Moderately	75–85
Slightly	85–95
Very slightly	95–100
Border width (percentage relative to pygidial sagittal length)	
Narrow	0–15
Moderate	15–25
Wide	25–greater

increasing in width posteriorly. Cranidium smooth, glabella with slightly divergent, slightly concave to straight axial furrows; frontal lobe slightly smaller than greatest glabellar width.

DESCRIPTION. Cranidium large, length 8.8–19.1 mm; subpentagonal, length 70–75% width; moderate sagittal and low transverse convexity, height 30–40% width; anterior margin strongly curved, anterior margin width 65–70% cranidial width; posterior margin, excluding occipital ring,

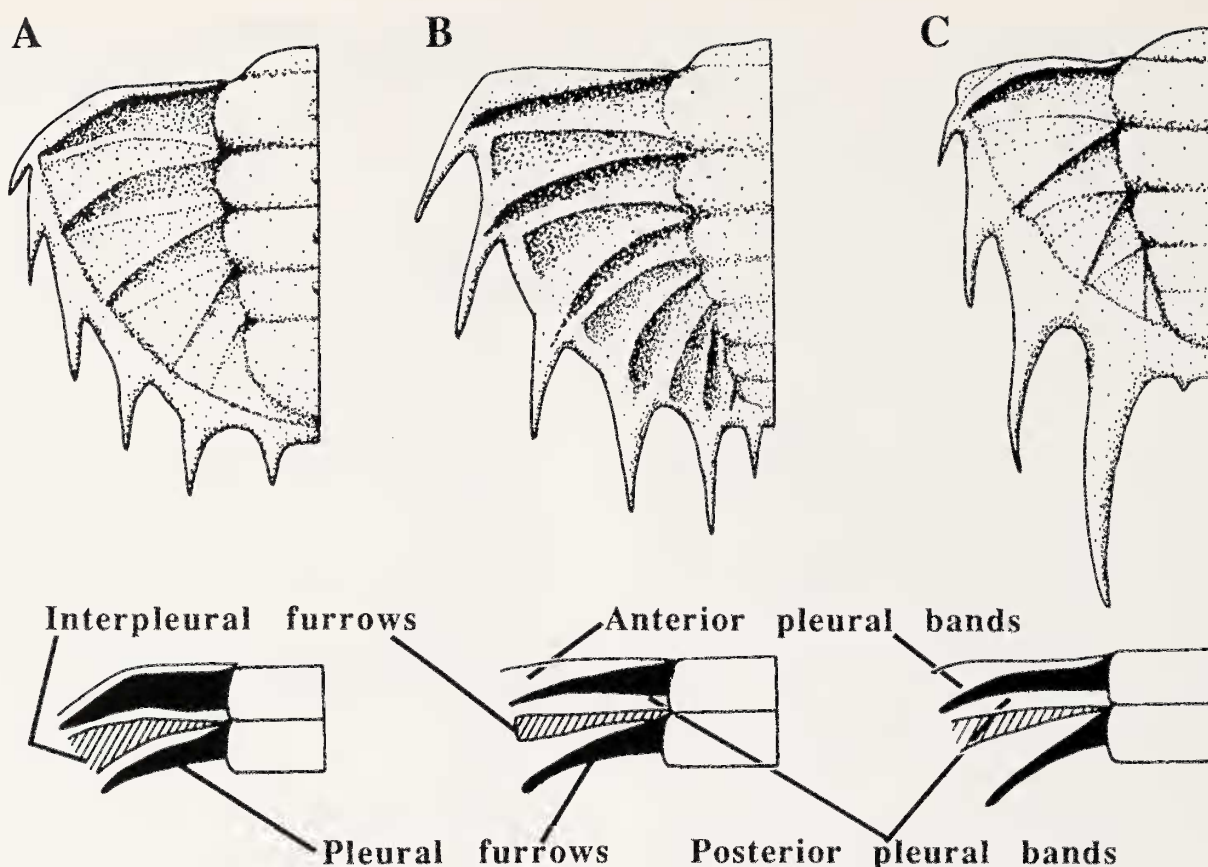


Figure 12. Pattern of pleural and interpleural furrows. **A**, *Kootenia dawsoni*, **B**, *Olenoides serratus*, **C**, *Dorypyge swasii*. Lower drawings are diagrammatic representations of pleural furrow (black) and interpleural furrow (cross-hatched) relationships of the above drawings. The anterior pleural band is anterior of the pleural furrow and the posterior pleural band is posterior of the pleural furrow.

straight to slightly backswept. Facial sutures straight from ends of palpebral lobes to the anterior border furrow; strongly convergent across anterior border; divergent moderately strong posterior of palpebral lobes. Glabella elongate, length 97–98% and width 50–60% cranial length; glabella width 35–45% cranial width; slightly expanding, width at anterior end 100–110% glabellar width, frontal lobe width slightly smaller than widest expansion at anterior end; moderate to moderately high convexity (sag. and trans.); anterior end rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, slightly shallower adjacent to lobe L3, absent adjacent to frontal lobe, slightly concave; preglabellar furrow shallow medially, deeper laterally, moderately curved, shallower than axial furrow; lateral glabellar furrows very shallow, F1 directed slightly posteriorly, F2 and F3 directed laterally. Occipital ring sagittal length 20–25% glabellar length, not elevated above glabella, moderately convex; moderate length, narrow occipital spine projecting dorsally and posteriorly; furrow curved posteriorly, moderately deep laterally, shallow medially, uniform depth medially; posterior margin curved. Frontal area length 2–3% cranial length. Preglabellar field absent. Anterior border slightly convex, level, widening laterally, evenly curved in front of glabella, slightly curved to straight laterally. Anterior border furrow evenly curved in front of glabella, straight laterally, shallow, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 35–50% glabellar width, low convexity, slightly

downsloping. Palpebral lobe narrow, width 15–30% lobe length; short, length 20–25% glabellar length; anterior margin located adjacent to 40–45% glabellar length from anterior margin of frontal lobe; furrow shallow depth, wide. Ocular ridge moderate strength, joins with glabella at deep fossula, directed very strongly posterolaterally from glabella at 45–50° to axial trend. Posterior area of fixigena exsagittal width 20–30% glabellar length; length 40–50% glabella length; terminates moderately round. Posterior border moderately low convexity, uniform width; border furrow moderately deep shallowing and widening laterally, curved slightly posterior.

Librigena large, length 18.0 mm; moderately wide, width approximately 45% length without spine; lateral margin moderately curved. Genal field slightly convex, width approximately 30% librigenal width. Border width approximately 55% librigenal width; slightly convex, level; lateral border furrow very shallow, very broad, shallowing posteriorly; posterior border furrow shallow, broad, very short. Genal spine long.

Hypostoma fused with rostrum; moderate size, length 10.6–12.1 mm; subtriangular, length 145–150% width, strong convexity (sag. and trans.), height 50% width; anterior margin strongly curved; lateral margins slightly cusped, converging; posterior margin slightly curved. Median body strongly convex (sag. and trans.); slightly suboval shaped; macula not evident. Posterior lobe narrow, low convexity; furrow shallow. Anterior border not defined, fused

with rostral plate; border furrow absent. Lateral borders poorly defined anteriorly, narrow, 10% of hypostoma width, well defined posteriorly; convex posteriorly, posterior wings slightly projecting, deep to moderately deep border furrow. Posterior border narrow, 5% hypostoma length, strongly convex; border furrow narrow, moderately deep. Rostral plate weakly convex; narrow medially, 4% hypostoma length, widening and slightly upsloping laterally, 15% hypostoma length, projecting slightly posterolaterally.

Thorax unknown.

Pygidium moderate size to large, length 6.0–15.2 mm; subcircular, length 60–65% width; anterior margin slightly curved posteriorly; lateral margins evenly curved; posterior margin slightly curved to straight; 5 pairs of spines, narrow to moderate width at base, level to slightly downsloping, most anterior positioned spines small, next 3 spine pairs increasing in length and base width posteriorly, most posterior pair very short; high to moderate convexity (sag. and trans.), height 30–45% width. Axis slightly tapered, axial mid-width 85–90% axial anterior width, projecting into border, axial anterior width 35–40% pygidial width; axial length 85–90% pygidial length, no postaxial ridge; 4 axial rings, moderate convexity, no axial nodes; terminal axial piece broadly rounded; axial furrows moderately shallow; axial ring furrows shallow to very shallow, deepening laterally. Pleural regions well defined, sagittally elongate, triangular shaped; moderate convexity, moderately downsloping; anterior pleural furrow broad, moderately shallow, extends to margin, curved slightly posterior; 3 additional pleural furrows, shallow to very shallow, extending into border; interpleural furrows shallow to very shallow; anterior pleural band expanding in width laterally, posterior pleural band not expanding in width laterally. Border narrow anteriorly widening posteriorly, medial width (projected) 5–10% pygidial length; very slightly convex, downsloping; border furrow shallow to very shallow, narrow, shallower than pleural furrows.

Exoskeleton thin; smooth on all external and internal surfaces.

REMARKS. *Dorypyge swasii* differs from other species of *Dorypyge* in its progressively increasing spine length of the four anterior pairs of pygidial spines, smooth exoskeleton, and larger frontal lobe of the glabella. The cranidium of *D. swasii* is more typical of *Kootenia* or *Olenoides* with its relatively large frontal lobe, but the pygidium is unlike species of these genera in its spine characters, widening border, and/or anterior pleural band expanding in width laterally. *Kootenia quadriceps* does have pygidial spine lengths that increase with each posterior set of spines (Palmer, 1954:pl. 14, fig. 2), but *D. swasii* differs in its spine lengths, fewer number of spines, and border width. This is the first recorded occurrence of the genus from the North American craton.

ETYMOLOGY. Latinized, named after the Swasey Limestone.

HOLOTYPE. Pygidium (LACMIP 11683) from the Swasey Limestone, Drum Mountains, Utah (LACMIP locality 15492).

PARATYPES. LACMIP 11676 from LACMIP locality 15528; LACMIP 11677–11682 from LACMIP locality 15490; LACMIP 11684–11688 from LACMIP locality 15492; LACMIP 11787 from LACMIP locality 15494.

OTHER MATERIAL. LACMIP locality 15489, 2 cranidia, 3 pygidia, 3 librigenae; LACMIP locality 15490, 18 cranidia, 7 pygidia, 1 hypostoma; LACMIP locality 15491, 1 cranidium, 2 pygidia, 1 hypostoma; LACMIP locality 15492, 16 cranidia, 6 pygidia, 4 hypostomata, 2 librigenae; LACMIP locality 15493, 4 cranidia, 1 pygidium, 1 hypostoma; LACMIP locality 15494, 5 cranidia, 3 pygidia; LACMIP locality 15514, 1 cranidium?; LACMIP locality 15528, 54 cranidia, 1 librigena, 15 pygidia; LACMIP locality 15529, 34 cranidia, 10 pygidia; LACMIP locality 15530, 5 cranidia, 2 pygidia; LACMIP locality 15531, 4 cranidia; LACMIP locality 15532, 10 cranidia, 5 pygidia; LACMIP locality 15533, 5 cranidia, 1 pygidium; LACMIP locality 15534, 5 cranidia.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains, ?House Range, Utah. Trailer Limestone, Dugway Range, Utah.

Genus *Kootenia* Walcott, 1889

TYPE SPECIES. *Bathyriscus (Kootenia) dawsoni* Walcott, 1889.

EMENDED DIAGNOSIS. Dorypygidae with cranidium with medially expanded to anteriorly expanded glabella, nearly effaced lateral glabellar furrows; fixigenae convex, slightly downsloping. Pygidium with well-defined axis generally extending to border, 3–5 ring furrows; pleural fields crossed by 3–5 generally deep pleural furrows; interpleural furrows very shallow to effaced, both anterior and posterior pleural bands uniform in width; border moderately defined, generally 5–7 pairs of spines of equal length, evenly spaced along margin.

REMARKS. The emended diagnosis is modified from Palmer (1968:47) to include additional pygidial characteristics. The pygidium of *Kootenia* has both anterior and posterior pleural bands that are uniform in width (Fig. 12), which can be used to distinguish it from pygidia of both *Dorypyge* and *Olenoides*.

Kootenia has approximately 110 named species (Palmer and Halley, 1979), with species defined almost entirely on pygidial characters. Lengths, basal widths, curvature, count, and direction of flexure (dorsally, ventrally, or flat) of the pygidial spines are among the most important features. Other important features include the length of the pygidial axis, nodes on the axis, surface ornamentation, and glabellar length. A study of the intraspecific stability of characters considered to be of taxonomic importance in *Kootenia* has not been undertaken. Specimens of *Kootenia dawsoni* from the Dome Limestone (Fig. 14) show considerable variation among several “taxonomically important” characters, including pygidial spine length, curvature of

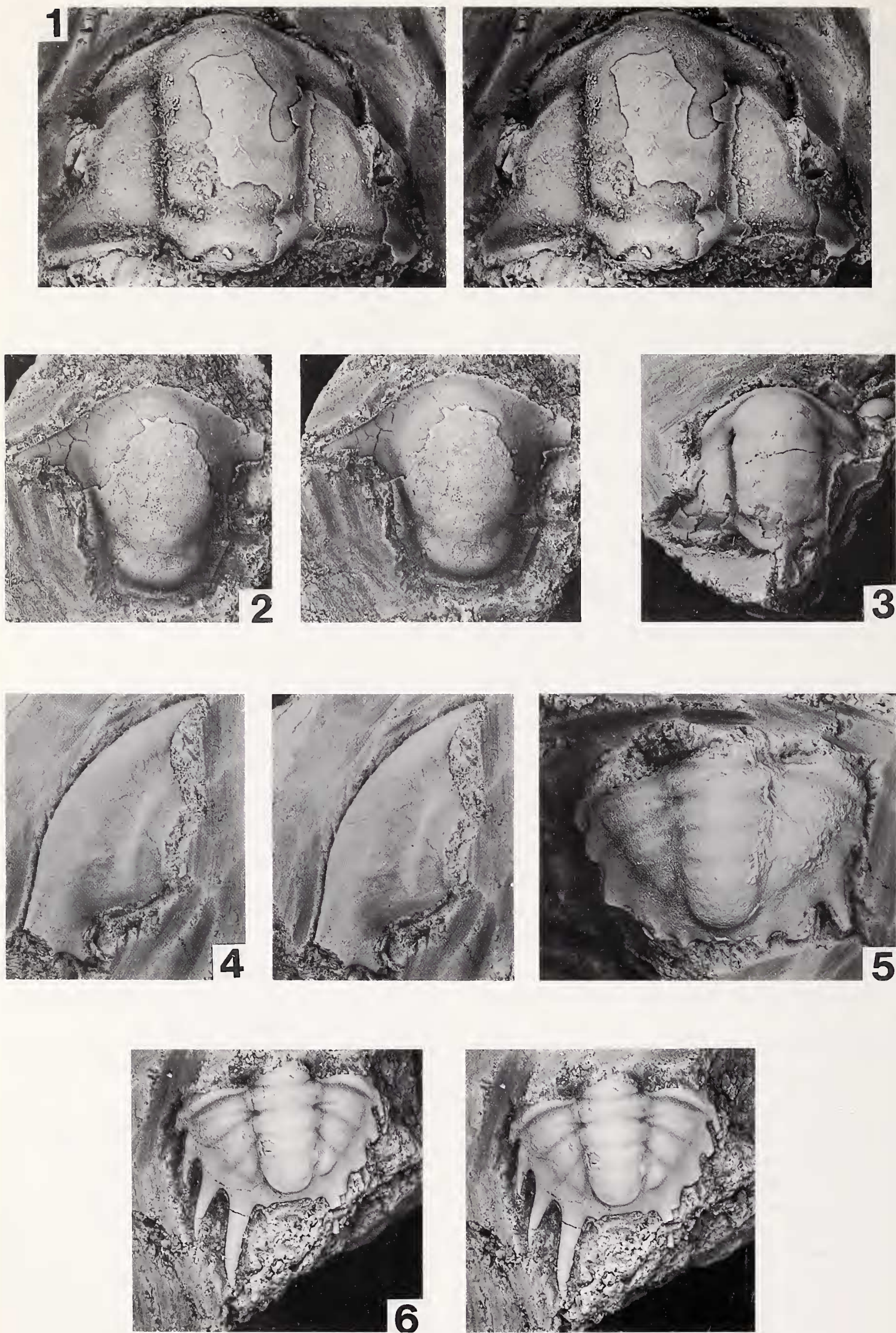


Figure 13. *Dorypyge swasii*, new species. 1, Stereo pair of paratype cranidium (LACMIP 11677), LACMIP locality 15490, mostly exfoliated, $\times 2.0$. 2, Stereo pair of paratype hypostoma (LACMIP 11684), LACMIP locality 15492, partly exfoliated, $\times 2.9$. 3, Small paratype cranidium (LACMIP 11676), LACMIP locality 15528, partly exfoliated, $\times 2.3$. 4,

spines, development of pygidial axial nodes (spines), depth of axial ring furrows, and depth of pleural furrows. However, the same specimens are consistent in pygidial spine count, spine basal widths, width of pygidial border, depth of border furrow relative to pleural furrow depth, pleural furrow depth, length and width of pygidial axis, and shape of terminal axial piece. It is possible that more than one species is represented by the specimens from the Dome Limestone, but the few specimens present in the collection would make it difficult to define them. The amount of variation in the specimens from the Dome Limestone suggests that *Kootenia* has been oversplit and that a major morphometric analysis of the species of *Kootenia* is needed. An example of oversplitting may be the naming of six species by Deiss (1939) from cranidia and pygidia derived from approximately 4 m of section (Deiss, 1938:1087, locality 10-2). The pygidia of the six species show only minor variations in their width/length, axis length/pygidial length, axis width/width, and height/pygidial width ratios.

Kootenia dawsoni (Walcott, 1889)

Figure 14

Bathyriscus (*Kootenia*) *dawsoni* Walcott, 1889: 446.

Dorypyge dawsoni (Walcott), Matthew, 1899:56, pl. 3, fig. 1.

Dorypyge (*Kootenia*) *dawsoni* (Walcott), Walcott, 1908b:pl. 3, fig. 9.

Kootenia dawsoni (Walcott), Walcott, 1918:131; Rasetti, 1951:189, pl. 27, figs. 4-7.

Kootenia buttsi Resser, 1938a:80, pl. 7, figs. 16-17.

EMENDED DIAGNOSIS. *Kootenia* with pygidium having 6 pairs of moderately thin, short to moderate length spines; 4-5 axial rings; weak to strong axial nodes; moderately shallow pleural furrows; and narrow border (5-15% pygidial length). Cranidium with slightly divergent, convex axial furrows, short palpebral lobes (20-25% glabella length).

EMENDED DESCRIPTION. Cranidium moderate size to large, length 7.5-15.4 mm; subpentagonal, length 60-70% width; moderate sagittal and low transverse convexity, height 30-45% width; anterior margin moderately curved, anterior margin width 65-75% cranial width; posterior margin, excluding occipital ring, straight to very slightly backswept. Facial sutures straight to slightly convergent from ends of palpebral lobes to anterior border; moderately convergent across anterior border; moderately divergent posterior of palpebral

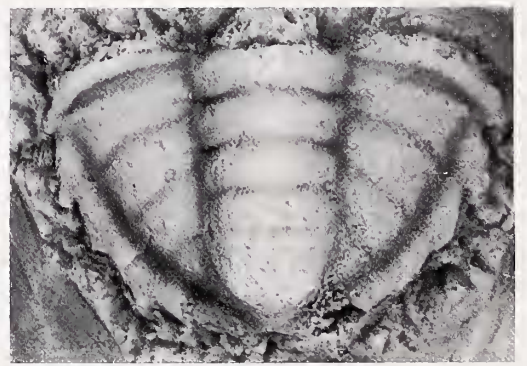
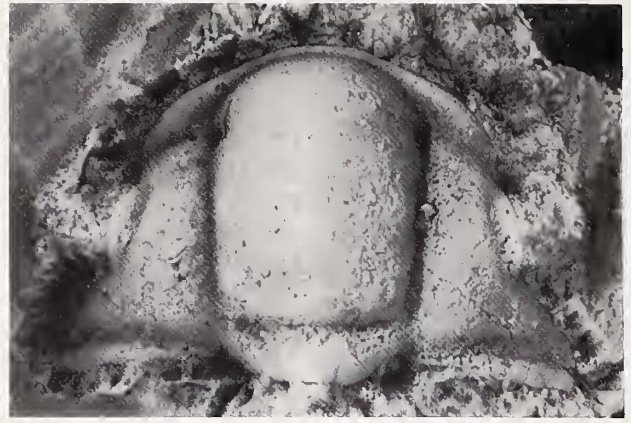
lobes. Glabella elongate, length 95-97% and width 55-60% cranial length; glabella width 35-40% cranial width; slightly expanding, width at anterior end 100-110% glabellar width, frontal lobe width slightly smaller than widest expansion at anterior end; high convexity (sag. and trans.); anterior end bluntly rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, slightly shallower adjacent to lobe L3, slightly convex; preglabellar furrow moderately deep, moderately curved, shallower than axial furrow; lateral glabellar furrows very shallow, F1 furrow directed posteriorly, bifurcated; F2 furrow straight, F3 furrow directed anteriorly. Occipital ring sagittal length 15-20% glabellar length, not elevated above glabella, moderately convex; very short, narrow occipital spine; furrow curved posteriorly, slightly deeper laterally, uniform depth medially, shallow depth; posterior margin curved. Frontal area length 3-5% cranial length. Preglabellar field absent. Anterior border moderately convex, upsloping, widening laterally, evenly curved in front of glabella, straight laterally. Anterior border furrow evenly curved in front of glabella, less curvature laterally, moderately deep, medially shallower than axial furrows, laterally as deep as axial furrows. Fixigena width, exclusive of palpebral lobe, 35-45% glabellar width, moderately low convexity, slightly downsloping. Palpebral lobe narrow, width 15-30% lobe length; short, length 20-25% glabellar length; anterior margin located adjacent to 35-40% glabellar length from anterior margin of frontal lobe; furrow moderate depth, wide. Ocular ridge weak, joins with glabella at deep fossula directed strongly posterolaterally from glabella at 45-50° angle to axial trend. Posterior area of fixigena exsagittal width 30-35% glabellar length; length 45-50% glabella length; terminates moderately round. Posterior border moderately low, convex, wider distally; border furrow moderately deep shallowing laterally, straight.

Librigena large, length 15.0 mm; moderately narrow, width 40-45% length without spine; lateral margin moderately curved. Genal field moderately convex, width 30-35% librigenal width. Border width 40-45% librigenal width; strongly convex, level; lateral border furrow moderately deep, broad, uniform depth; posterior border furrow shallow, broad, very short. Genal spine long, 60-65% librigenal length.

Hypostoma fused with rostrum; small, length 5.0 mm; subrectangular, length 145% width, strong convexity (sag. and trans.), height 40-45% width; anterior margin moderately curved; lateral margins scalloped, parallel; posterior margin slightly rounded. Median body strongly convex (sag. and trans.);

←

Stereo pair of paratype free cheek (LACMIP 11787), LACMIP locality 15494, exfoliated, $\times 2.5$. 5, Large paratype pygidium with larger spines broken (LACMIP 11682), LACMIP locality 15490, exfoliated, $\times 1.8$. 6, Stereo pair of smaller holotype pygidium (LACMIP 11683), LACMIP locality 15492, not exfoliated, $\times 3.6$.



anterior lobe oval to slightly egg shaped with widest dimension anteriorly; posterior lobe narrow, poorly defined. Anterior border not defined, fused with rostral plate; border furrow shallow laterally, deeper medially. Lateral border poorly defined anteriorly, moderate relief posteriorly; strongly convex posteriorly, posterior wings slightly projecting; border furrow moderately shallow, broad. Posterior border wide, 5% hypostoma length, slightly concave, wider laterally; border furrow moderately shallow, broad. Rostral plate narrow medially, 5% hypostoma length, slightly widening and level laterally, 6% hypostoma length, moderately strong convex.

Seven thoracic segments, axial rings transversely moderately wide. Pleura sagittally and transversely moderately wide, deep pleural furrow, convex pleural lobes; posteriorly directed sharp terminations.

Pygidium moderate size, length 6.8–12.6 mm; subcircular, length 60–65% width; anterior margin slightly curved posteriorly; lateral margins evenly curved; posterior margin evenly curved; 6 spines, narrow width at base, level, most anterior positioned spine least developed, spines very short to moderate length; high convexity (sag. and trans.), height 25–30% width. Axis moderately to slightly tapered, axial mid-width 80–95% axial anterior width, axial anterior width 30–40% pygidial width; axial length 90–95% pygidial length, short low relief postaxial ridge; 4–5 axial rings, high convexity, weak to strong nodes; terminal axial piece broadly rounded; axial furrows moderately shallow; axial ring furrows shallow to very shallow, uniform depth. Pleural regions well defined, sagittally elongate, triangular shaped; moderate to high convexity, strongly downsloping; anterior pleural furrow broad, moderately shallow, extends to margin, curved slightly posterior; 3–4 additional pleural furrows, shallow to very shallow; interpleural furrows shallow to very shallow. Border narrow, width 5–10% pygidial length; moderately convex, level; border furrow shallow, broad, deeper than pleural furrows.

Exoskeleton thin; smooth on all external and internal surfaces.

REMARKS. *Kootenia dawsoni* specimens from the Dome Limestone agree well with the specimens illustrated by Rasetti (1951) from the Stephen Formation of British Columbia. Most pygidia in the Dome Limestone collections have shorter spines than those illustrated by Rasetti, but Poulsen (in

Harrington et al., 1959) considered spine lengths to variable within a species. The variability of spine length within a species is also supported by the range of spine length found on specimens of *K. dawsoni* from one bed. The emended diagnosis and descriptions are based on the figured specimens of Rasetti (1951) and the specimens collected for this study.

Specimens from the Eldorado Formation are questionably assigned to *K. dawsoni*. A complete pygidium from this section was broken next to the axial furrow after deposition, thus giving it a higher width/length ratio than is typical for the species. The complete cranidium from the same section is transversely narrower than is typical for the species. Without more complete specimens from the Eldorado Formation, I cannot determine if these specimens represent a different species from specimens in the Dome Limestone.

The specimens of *K. buttsi* figured by Resser (1938a) are distorted, but in all taxonomically important criteria they do not differ from *K. dawsoni*.

Kootenia dawsoni is similar to *K. florens* Suvorova, 1964, in the shape of the glabella and pygidium, but contains six pairs of pygidial spines and the distance from the ocular ridges to the anterior border is less. *Kootenia dawsoni* is also similar to *K. ontoensis* Tchernysheva, 1961 (illustrated in Suvorova, 1964), but differs in a less curved anterior border, a non-medially inflated glabella, broader based spines, and wider (exsag.) and shorter (trans.) posterior area of fixigena.

HYPOTYPES. KUMIP 204738–204741 from RC locality 211; KUMIP 204742–204745 from RC locality 374.

OTHER MATERIAL. RC locality 107, 3 cranidia, 1 librigena, 3 pygidia; RC locality 211, 12 cranidia, 6 hypostomata, 1 librigena, 12 pygidia; RC locality 374, 13 cranidia, 5 hypostomata, 4 librigenae, 13 pygidia; LACMIP locality 15465, 2 pygidia; LACMIP locality 15503, 2 cranidia, 1 librigena, 4 pygidia; LACMIP locality 15558, 1 pygidium; LACMIP locality 15594, fragmented cranidia and pygidia; LACMIP locality 15595, 1 complete cranidium, several fragmented cranidia, librigenae, hypostomata, 1 complete pygidium, and fragmented pygidia.

OCCURRENCE. *Ehmaniella* Biozone. Stephen Formation, British Columbia (Rasetti, 1951). Rutledge Limestone?, Alabama (Resser, 1938a). Dome Limestone, House Range, Utah. Whirlwind For-

Figure 14. *Kootenia dawsoni* (Walcott). 1, Stereo pair of cranidium (KUMIP hypotype 204739), locality RC 211, exfoliated, $\times 4.0$. 2, Partial large cranidium (KUMIP hypotype 204743), RC locality 374, mostly exfoliated, $\times 2.5$. 3, Stereo pair of free cheek (KUMIP hypotype 204745), RC locality 374, partially exfoliated, $\times 1.7$. 4, Partial cranidium (KUMIP hypotype 204738), RC locality 211, exfoliated, $\times 2.5$. 5, Stereo pair of hypostoma (KUMIP hypotype 204741), RC locality 211, slightly exfoliated, $\times 6.4$. 6, Partial pygidium (KUMIP hypotype 204744) with longer spines and axial nodes, RC locality 374, mostly exfoliated, $\times 2.8$. 7, Stereo pair of pygidium (KUMIP hypotype 204742) with shorter spines and no axial nodes, RC locality 374, exfoliated, $\times 3.6$. 8, Stereo pair of pygidium (KUMIP hypotype 204740) with very small spines and small axial nodes, RC locality 211, exfoliated, $\times 2.5$.

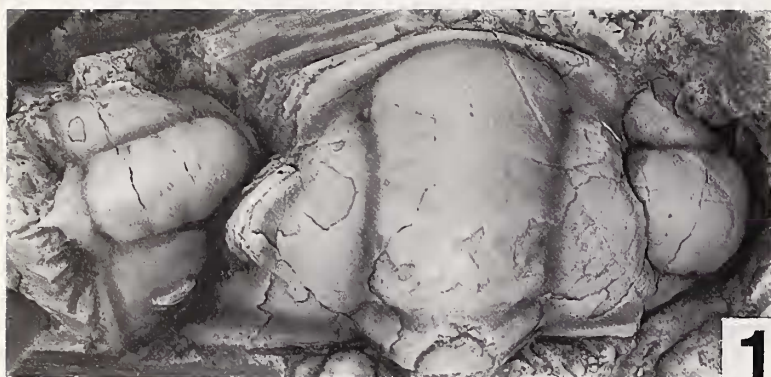


Figure 15. *Kootenia* cf. *K. dawsoni* (Walcott). 1, Distorted cranidia (hypotypes, left = USNM 468961 and center = USNM 468962), locality USGS 1982-CO, partially exfoliated, $\times 2.1$. 2, Distorted cranidium (USNM hypotype 468963) and pygidium (USNM hypotype 468964), locality USGS 1982-CO, not exfoliated, $\times 2.0$. 3, Stereo pair of undistorted pygidium (LACMIP hypotype 11692), LACMIP locality 15578, exfoliated, $\times 4.2$.

mation, Drum Mountains, Utah. ?Eldorado Formation, northern Egan Range, Nevada. Pole Canyon Limestone, Member E, Snake Range, Nevada.

Kootenia cf. *K. dawsoni*
(Walcott, 1889)

Figure 15

REMARKS. This species differs from *Kootenia dawsoni* by the cranidium having concave axial furrows, longer palpebral lobes, and a longer occipital spine. The pygidia of this species are more transversely elongate and never show the development of axial nodes seen in some specimens of *K. dawsoni*. A detailed description and diagnosis are not presented and the nomenclature is left open because of either the tectonic distortion or the fragmentary nature of all known specimens of *K. cf. K. dawsoni*.

HYPOTYPES. LACMIP 11692 from LACMIP locality 15578; USNM 468961–468964 from USGS locality 1982-CO.

OTHER MATERIAL. USGS CO-1982, 5 cranidia, 3 hypostomata, 5 pygidia; LACMIP locality 15562, 1 cranidium, 4 pygidia.

OCCURRENCE. *Elrathiella* Subzone?, *Ehmaniella* Biozone. Pole Canyon Limestone, Member E, Snake Range, Nevada; Patterson Pass, Nevada.

Kootenia acicularis Resser, 1939b
Figure 16

Kootenia acicularis Resser, 1939b:49, 50, pl. 10, figs. 24–26.

EMENDED DIAGNOSIS. *Kootenia* with pygidium having 6 pairs of moderately thin, long spines; 4 axial rings; no axial nodes; moderately deep pleural furrows; and narrow border (5–15% pygidial length). Cranidium with slightly divergent, concave axial furrows; moderate length palpebral lobes (30–35% glabellar length).

EMENDED DESCRIPTION. Cranidium moderate size, length 6.6–10.6 mm; subpentagonal, length 65–85% width; high sagittal and moderate transverse convexity, height 30–50% width; anterior margin strongly curved, anterior margin width 50–70% cranial width; posterior margin, excluding occipital ring, straight to slightly backswept. Facial sutures slightly convergent from ends of palpebral lobes to anterior border; moderately to strongly convergent across anterior border; moderately divergent posterior of palpebral lobes. Glabella elongate, length 94–98% and width 45–55% cranial length; glabella width 30–45% cranial width; slightly expanding, width at anterior end 105–115% glabellar width, frontal lobe width slightly smaller than widest expansion at anterior end; high convexity (sag. and trans.); anterior end bluntly rounded, 3 lateral glabellar lobes. Axial furrows deep, uniform depth, slightly concave; preglabellar furrow moderately shallow, moderately curved, shallower than axial furrow; lateral glabellar furrows very shallow to absent. Occipital ring sagittal length 15–20% glabellar length, not elevated above glabella, strongly convex; short, narrow occipital spine directed dorsally; furrow curved posteriorly, slightly deeper laterally, shallowing medially; posterior margin curved. Frontal area length

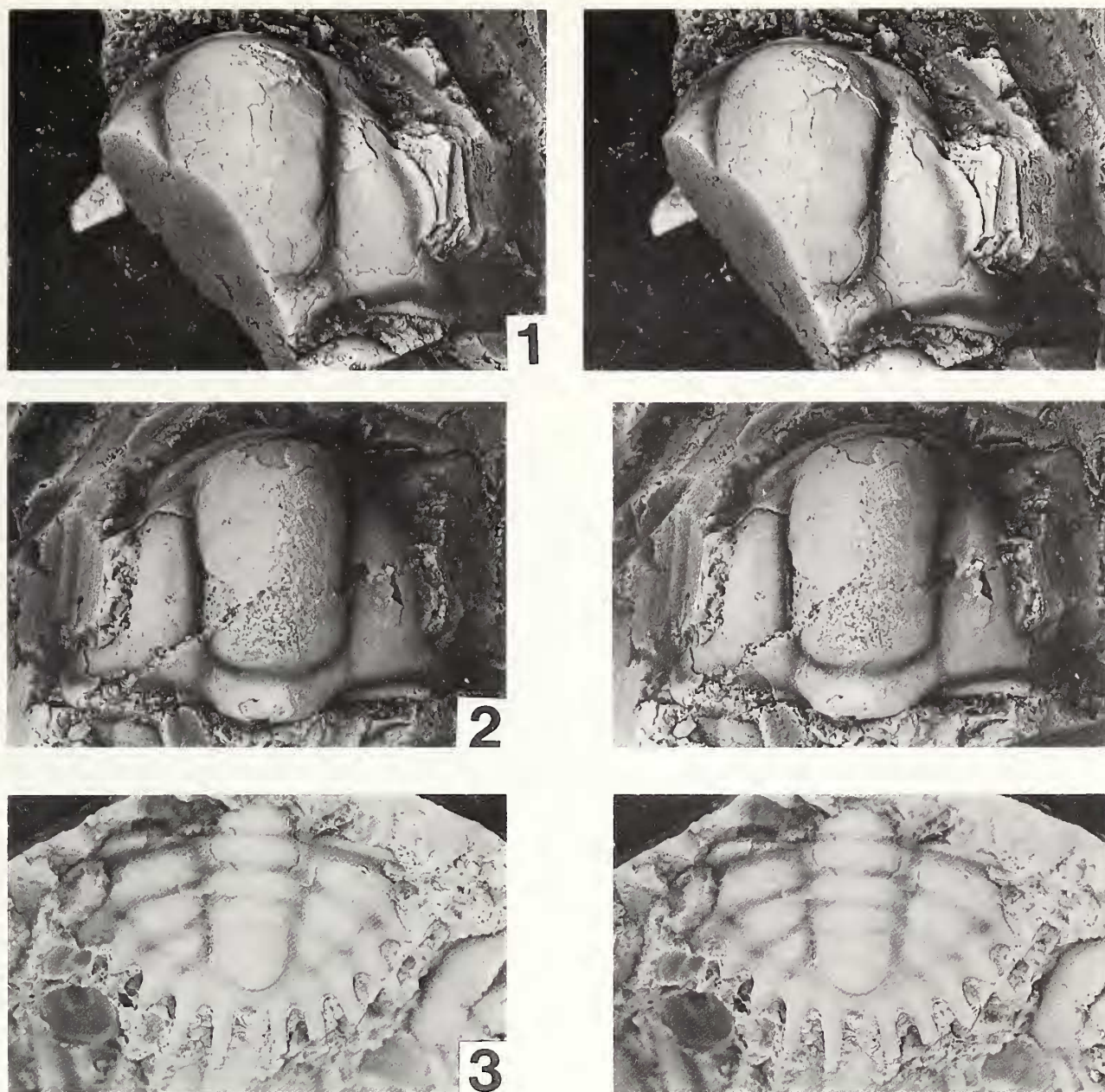


Figure 16. *Kootenia acicularis* Resser. 1, Stereo pair of fragmentary cranidia (LACMIP hypotype 11689), LACMIP locality 15548, mostly exfoliated, $\times 3.1$. 2, Stereo pair of cranidium (LACMIP hypotype 11690), LACMIP locality 15548, partially exfoliated, $\times 2.9$. 3, Stereo pair of latex cast of pygidium (LACMIP hypotype 11691), LACMIP locality 15548, mostly exfoliated, $\times 2.8$.

2–6% cranidial length. Preglabellar field absent. Anterior border moderately convex, downsloping, widening laterally, evenly curved in front of glabella, straight laterally. Anterior border furrow evenly curved in front of glabella, less curvature laterally, moderately shallow, uniform depth, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 45–50% glabellar width, moderate convexity, level. Palpebral lobe narrow, width 20–30% lobe length; moderate length, length 30–35% glabellar length; anterior margin located adjacent to 35–40% glabellar length from anterior margin of frontal lobe; furrow moderate depth, wide. Ocular ridge weak, joins with glabella just below shallow fossula, directed strongly posterolaterally from glabella at approximately 40° to axial trend. Posterior area of fixigena exsagittal width 15–20% glabellar length; length 40–50% glabella length; roundly terminated. Posterior border strongly convex, wider distally; border furrow moderately deep shallowing laterally, curving posteriorly.

Librigena, hypostoma, and thorax unknown.

Pygidium moderate size, length 6.6–11.0 mm; semicircular, length 50–60% width; anterior margin slightly curved posteriorly; lateral margins evenly curved; posterior margin evenly curved; 6 spines, downsloping, most anterior positioned spine least developed, spines long; moderate convexity (sag. and trans.), height 20–30% width. Axis moderately tapered, axial mid-width 80–85% axial anterior width, axial anterior width 30–35% pygidial width; axial length 85–95% pygidial length, no postaxial ridge; 4 axial rings, high convexity, no nodes; terminal axial piece broadly rounded; axial furrows moderately shallow; axial ring furrows shallow, shallowing medially. Pleural regions well defined, sagittally elongate, triangular shaped; high convexity, strongly downsloping; anterior pleural furrow broad, deep, extends to margin, curved slightly posterior; 3 additional pleural furrows, moderate depth to shallow, forming moderate depth pits on border; interpleural furrows very shallow to effaced. Anterior border narrow, width 5–15% pygidial length;



Figure 17. *Kootenia* cf. *K. havasuensis* Resser. 1, Stereo pair of partial cranidium (LACMIP hypotype 11693), LACMIP locality 15583, exfoliated, $\times 2.0$. 2, Stereo pair of partial pygidium (LACMIP hypotype 11694), LACMIP locality 15583, partially exfoliated, $\times 2.3$.

moderately convex between pits, level; border furrow shallow, moderately narrow.

Exoskeleton thin; smooth on all external and internal surfaces.

REMARKS. The emended diagnosis and descriptions are based on the figured specimens of Resser (1939b) and the specimens collected for this study. *Kootenia acicularis* was originally reported from the *Ptarmigania* strata of the Langston Limestone in the Wasatch Mountains (Resser, 1939b). The *Ptarmigania* fauna is from the *Glossopleura* Biozone. *Kootenia acicularis* from the Swasey Limestone and stratigraphically equivalent units is of the upper *Ehmaniella* Biozone. The pygidia from this study differ from the specimen illustrated by Resser (1939b:pl. 10, fig. 26) in slightly lower width/length ratios (50–60% vs. 65%). The cranidium illustrated by Resser (1939b:pl. 10, fig. 24) is a juvenile and cannot be used to identify the species; thus, the comparison of the cranidia from this study to specimens illustrated by Resser is not valid. It is possible that the collections are not conspecific. However, without a mature cranidium from the type collection to compare to the specimens from the *Ehmaniella* Biozone, I cannot demonstrate that the two collections are different species.

HYPOTYPES. LACMIP 11689–11691 from LACMIP locality 15548.

OTHER MATERIAL. LACMIP locality 15495, 1 cranidium, 3 pygidia; LACMIP locality 15499, 2 cranidia, 2 pygidia; LACMIP locality 15544, 1 cranidium, 1 pygidium;

um; LACMIP locality 15545, 1 cranidium, 2 pygidia; LACMIP locality 15547, 1 cranidium, 3 pygidia; LACMIP locality 15548, 1 pygidium; LACMIP locality 15568, 1 pygidium; LACMIP locality 15580, 3 cranidia, 2 pygidia.

OCCURRENCE. *Glossopleura* Biozone–*Ehmaniella* Biozone. “Langston Limestone,” Wasatch Mountains, Utah. Swasey Limestone, Drum Mountains, Utah; Trailer Limestone, Dugway Range, Utah; and Pole Canyon Limestone, Member E, Snake Range and Patterson Pass, Nevada.

Kootenia cf. *K. havasuensis*

Resser, 1945

Figure 17

REMARKS. *Kootenia* cf. *Kootenia havasuensis* Resser is represented only by two partial pygidia and one partial cranidium. Because of the few specimens, the nomenclature of the species is left open. The pygidium of *Kootenia* cf. *K. havasuensis* is distinctive in its absence of marginal spines. The lateral and posterior margins of the pygidium are slightly undulating where spines would occur in typical *Kootenia* species. This feature is characteristic of *K. havasuensis* Resser, 1945, which is from either the uppermost *Glossopleura* or lowermost *Ehmaniella* biozones in the Muav Limestone of the Grand Canyon. The pygidium of *K. cf. K. havasuensis* differs from the pygidium of *K. havasuensis* in its lower width/length and height/width ratios and more posteriorly directed pleural furrows. The

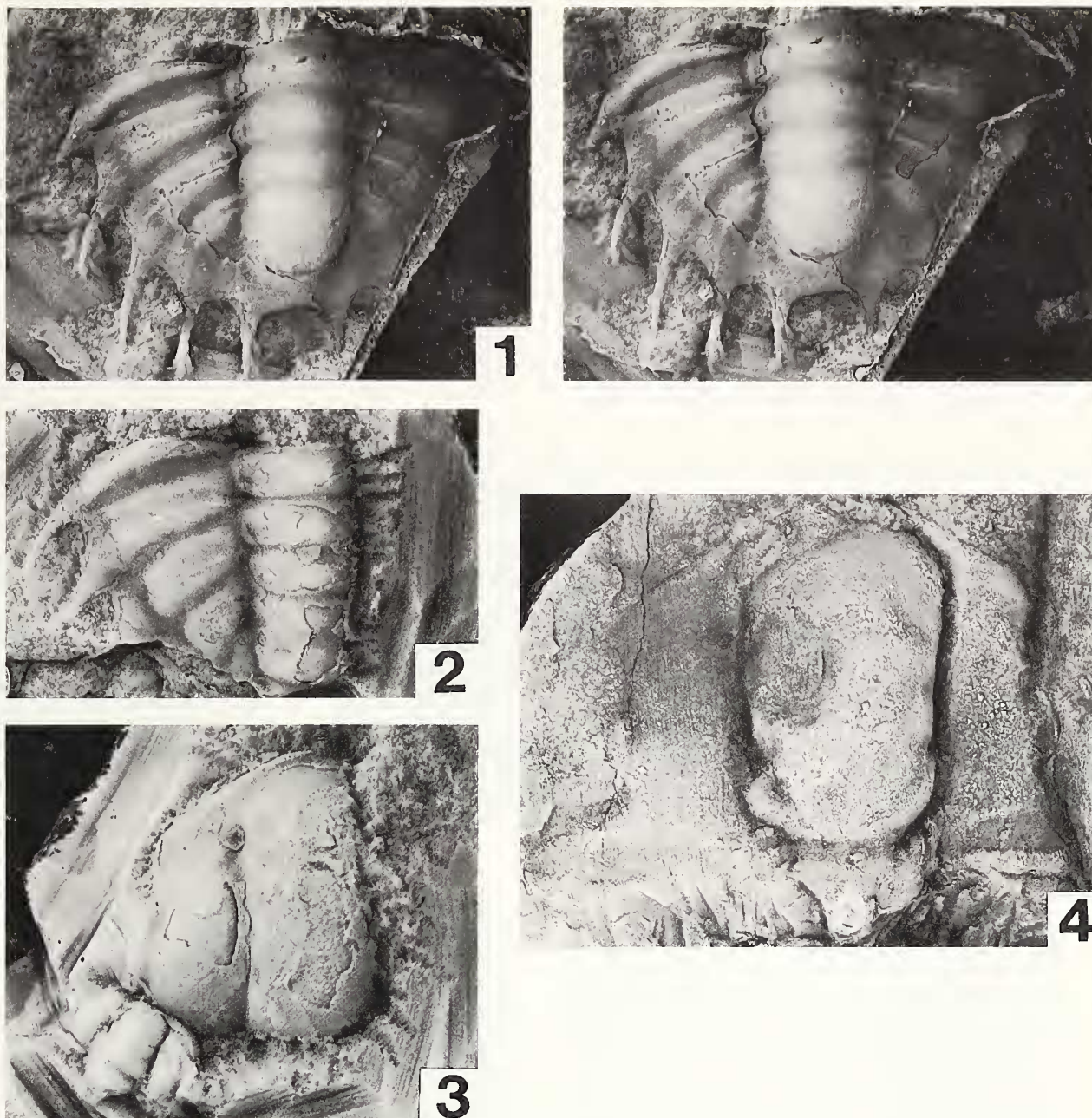


Figure 18. *Kootenia? margoindistincta*, new species. 1, Stereo pair of latex cast of partial holotype pygidium (LACMIP 11708), LACMIP locality 15513, partially exfoliated, $\times 2.1$. 2, Partial paratype pygidium (LACMIP 11706), LACMIP locality 15513, partially exfoliated, $\times 2.7$. 3, Partial paratype cranidium (LACMIP 11705), LACMIP locality 15513, partially exfoliated, $\times 2.7$. 4, Poorly preserved, compressed paratype cranidium (LACMIP 11707), LACMIP locality 15513, exfoliated, $\times 2.3$.

cranidium is unlike that of *K. havasuensis* in having a contracted frontal lobe. The cranidium is similar to *K. parallela* Rasetti, 1948, from the *Glossopleura* faunas of Quebec.

Kootenia cf. *K. havasuensis* is the earliest known species of *Kootenia* from the *Ehmaniella* Biozone.

HYPOTYPES. LACMIP 11693, 11694 from LACMIP locality 15583.

OTHER MATERIAL. LACMIP locality 15583, 1 pygidium.

OCCURRENCE. *Proehmaniella* Subzone, *Ehmaniella* Biozone. Eldorado Formation, northern Egan Range, Nevada.

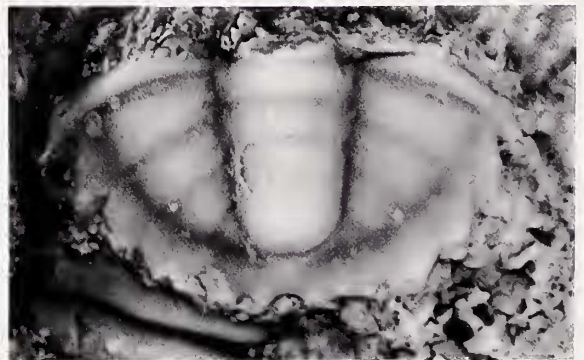
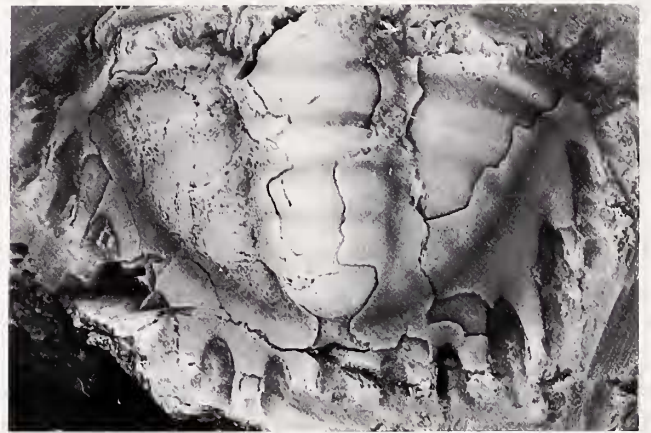
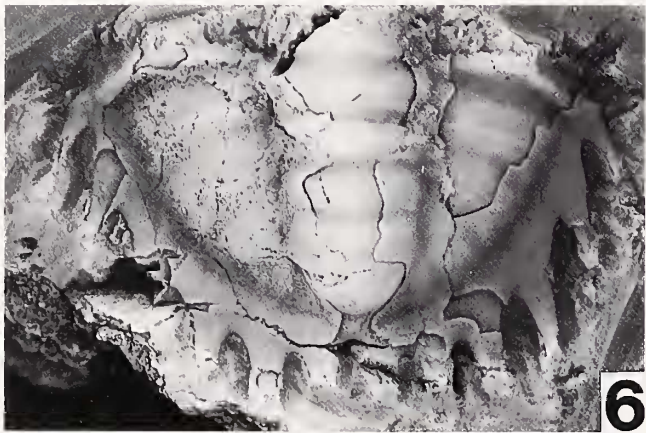
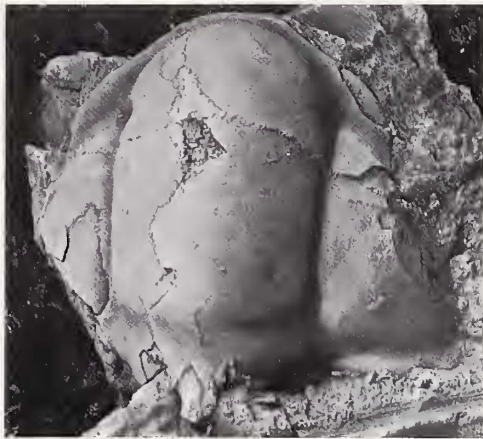
***Kootenia? margoindistincta*,
new species**

Figure 18

DIAGNOSIS. *Kootenia* with pygidium having 5 pairs of thin, moderate length spines; 4 axial rings;

no axial nodes; moderately shallow pleural furrows; and border very poorly defined. Cranidium with parallel, concave axial furrows; short to moderate length palpebral lobes (15–30% glabellar length).

DESCRIPTION. Cranidium large, length 17.6–19.7 mm; subpentagonal, length approximately 60% width; low convexity (sag. and trans.); anterior margin strongly curved, anterior margin width approximately 65% cranidial width; posterior margin, excluding occipital ring, straight. Facial sutures slightly divergent to straight from ends of palpebral lobes to anterior border furrow; strongly convergent across anterior border; moderately divergent posterior of palpebral lobes. Glabella elongate, length approximately 95% and width approximately 50% cranidial length; glabella width approximately 30% cranidial width; expanding, frontal end; moderate convexity (sag. and trans.); anterior end bluntly rounded, 3 lateral glabellar lobes. Axial furrows moderately shallow to deep, parallel, concave; preglabellar furrow very shallow, moderately curved,



shallower than axial furrow, shallowing laterally; lateral glabellar furrows absent. Occipital ring sagittal length 15–20% glabellar length, not elevated above glabella, moderately convex; small spine; furrow curved posteriorly, slightly deeper laterally, uniform depth medially, shallow depth; posterior margin curved. Frontal area length approximately 5% cranial length. Preglabellar field absent. Anterior border slightly convex, level, widening laterally, evenly curved in front of glabella, straight laterally. Anterior border furrow evenly curved in front of glabella, less curvature laterally, very shallow, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 45–55% glabellar width, low convexity, level. Palpebral lobe narrow, width 15–20% lobe length; short, length 15–30% glabellar length; anterior margin located adjacent to 40–45% glabellar length from anterior margin of frontal lobe; furrow shallow depth, wide. Ocular ridge very weak, joins with glabella at deep fossula, directed very strongly posterolaterally from glabella at approximately 50° to axial trend. Posterior area of fixigena exsagittal width 20–30% glabellar length; length approximately 60% glabella length; terminates moderately round. Posterior border moderately low, convex, wider distally; border furrow moderate depth, straight.

Librigena, hypostoma, and thorax unknown.

Pygidium moderate size, length 11.8–12.6 mm, subcircular, length 55–60% width; anterior margin slightly curved posteriorly; lateral margins evenly curved; posterior margin evenly curved; 5 spines, narrow at base, level to slightly upturned posteriorly, most anterior positioned spine least developed, spines moderate length; moderate to high convexity (sag. and trans.), height approximately 25% width. Axis moderately tapered, axial mid-width 80–85% axial anterior width, axial anterior width 30–35% pygidial width; axial length 85–95% pygidial length, no postaxial ridge; 3 or 4 axial rings visible, high convexity, nodes absent; terminal axial piece broadly rounded; axial furrows moderately shallow; axial ring furrows shallow to very shallow, uniform depth, posterior furrow very shallow laterally absent medially. Pleural regions well defined, sagittally elongate, triangular shaped; low to moderate convexity, downsloping; anterior pleural furrow broad, moderately deep, extends to margin, curved slightly posterior; 3 additional pleural fur-

rows, moderately shallow to very shallow; interpleural furrows shallow to very shallow. Border narrow, width 5–15% pygidial length; moderately flat, level; border furrow very faint or absent.

Exoskeleton thin; smooth on all external and internal surfaces.

REMARKS. *Kootenia? margoindistincta* is represented by mostly fragmentary and flattened specimens; thus, ratios and angles are only approximate. *Kootenia? margoindistincta* is not typical of *Kootenia* in its indistinct pygidial border and the thinness and sharpness of the spines. These pygidial features are more typical of *Olenoides*, but the shallow interpleural furrows and the laterally uniform width of the anterior and posterior pleural bands suggest a closer affinity to *Kootenia* than to *Olenoides* (see Fig. 12).

ETYMOLOGY. Latin, *margo* = border, *indistinctus* = indistinct, for the relatively indistinct pygidial border.

HOLOTYPE. Pygidium (LACMIP 11708) from the Whirlwind Formation, House Range, Utah (LACMIP locality 15513).

PARATYPES. LACMIP 11705–11707 from LACMIP locality 15513.

OTHER MATERIAL. LACMIP locality 15512, 3 pygidia; LACMIP locality 15513, 3 cranidia, 6 pygidia.

OCCURRENCE. *Ehmaniella* Subzone, *Ehmaniella* Biozone, Whirlwind Formation. House Range, Utah.

Kootenia quadriceps (Hall and Whitfield, 1877)

Figure 19

Dikellocephalus quadriceps Hall and Whitfield, 1877:240, pl. 1, figs. 37–40.

Olenoides quadriceps (Hall and Whitfield), Walcott, 1886:187, pl. 29, figs. 1, 1a–c. Walcott, 1890:646, pl. 94, figs. 4, 4a–b. Lorenz, 1906:83, unnumbered fig.

Kootenia quadriceps (Hall and Whitfield), Resser, 1937:16. Palmer, 1954:65, pl. 14, figs. 1–3.

DIAGNOSIS. *Kootenia* with pygidium having 6 pairs of moderately thick, short to moderate length spines; 4 axial rings; no axial nodes; moderately shallow pleural furrows; and wider border (10–15% pygidial length). Cranidium with parallel, concave

Figure 19. *Kootenia quadriceps* (Hall and Whitfield). 1, Large cranidium (LACMIP hypotype 11704), LACMIP locality 15599, mostly exfoliated, $\times 2.2$. 2, Two hypostomata (left = LACMIP hypotype 11699 and right = LACMIP hypotype 11698), LACMIP locality 15526, exfoliated, $\times 7.3$. 3, Stereo pair of cranidium (LACMIP hypotype 11703), LACMIP locality 15599, partially exfoliated, $\times 2.0$. 4, Partial pygidium (LACMIP hypotype 11702), LACMIP locality 15535, exfoliated, $\times 2.9$. 5, Stereo pair of free cheek (LACMIP hypotype 11700), LACMIP locality 15535, exfoliated, $\times 6.6$. 6, Stereo pair of pygidium (LACMIP hypotype, 11695), LACMIP locality 15526, partially exfoliated, $\times 2.2$. 7, Stereo pair of small pygidium (LACMIP hypotype 11701), LACMIP locality 15535, not exfoliated, $\times 8.6$.

axial furrows; short palpebral lobes (20–25% glabellar length).

EMENDED DESCRIPTION. Cranidium large, length 12.0–17.7 mm; subpentagonal, length 80–85% width; moderately high sagittal and moderate transverse convexity, height 30–35% width; anterior margin moderately to strongly curved, anterior margin width approximately 70% cranial width; posterior margin, excluding occipital ring, straight to very slightly backswept. Facial sutures parallel to slightly convergent from ends of palpebral lobes to anterior border; moderately convergent across anterior border; divergent moderately strong posterior of palpebral lobes. Glabella elongate, length 96–97% and width 50–55% cranial length; glabella width 40–45% cranial width; slightly expanding, width at anterior end approximately 105% glabellar width, frontal lobe width slightly smaller than widest expansion at anterior end; high convexity (sag. and trans.); anterior end strongly rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, slightly convex; preglabellar furrow moderately shallow, moderately curved, shallower than axial furrow; lateral glabellar furrows very shallow to effaced, F1 furrow directed posteriorly; F2 furrow straight, F3 furrow directed anteriorly. Occipital ring sagittal length approximately 15% glabellar length, not elevated above glabella, low convexity; short, narrow occipital spine; furrow curved posteriorly, slightly deeper laterally, uniform depth medially, shallow depth; posterior margin curved. Frontal area length 3% cranial length. Preglabellar field absent. Anterior border slightly convex, level, widening laterally, evenly curved in front of glabella, straight laterally. Anterior border furrow evenly curved in front of glabella, less curvature laterally, shallow, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 35–55% glabellar width, low convexity, slightly downsloping. Palpebral lobe narrow, width 15–20% lobe length; short, length 20–25% glabellar length; anterior margin located adjacent to 40–45% glabellar length from anterior margin of frontal lobe; furrow moderate depth, wide. Ocular ridge weak, joins with glabella at deep fossula, directed strongly posterolaterally from glabella at 50–55° to axial trend. Posterior area of fixigena exsagittal width 25–35% glabellar length; length 35–40% glabella length; terminates moderately round. Posterior border moderately low, convex, wider distally; border furrow moderate depth, uniform depth, wide, straight.

Librigena moderate size, length 6.4 mm; narrow, width approximately 35% length without spine; lateral margin gently curved. Genal field flat, width approximately 15% librigenal width. Border width approximately 50% librigenal width; strongly convex, flat dorsally, level; lateral border furrow moderately deep, broad, shallowing posteriorly; posterior border furrow not present. Genal spine short, 25% librigenal length.

Hypostoma fused with rostrum; small, length 2.0–4.0 mm; subrectangular, length 140–160% width,

strong convexity (sag. and trans.), height 35–65% width; anterior margin moderately curved; lateral margins scalloped, parallel; posterior margin slightly rounded. Median body strongly convex (sag. and trans.); anterior lobe oval to slightly egg shaped with widest dimension anteriorly; posterior lobe narrow, poorly defined. Anterior border not defined, fused with rostral plate; border furrow shallow laterally, deeper medially. Lateral border poorly defined anteriorly, moderate relief posteriorly; strongly convex posteriorly, posterior wings slightly projecting; border furrow moderately shallow, broad. Posterior border wide, 5–10% hypostoma length, slightly concave, wider laterally; border furrow moderately shallow, broad. Rostral plate narrow medially, 3–4% hypostoma length, slightly widening and level laterally, 6–7% hypostoma length, moderately strong convex.

Thorax unknown.

Pygidium moderate size, length 2.6–12.1 mm; subcircular, length 55–65% width; anterior margin slightly to moderately curved posteriorly; lateral margins evenly curved; posterior margin evenly curved; 6 pairs of spines, moderately wide at base, level to upturned posteriorly, spines increase in length from short to moderate length from most anterior positioned spine to more posterior spines, posterior most spine pair short; moderate to high convexity (sag. and trans.); height 20–40% width. Axis slightly to moderately tapered, axial mid-width 75–90% axial anterior width, axial anterior width 30–35% pygidial width; axial length 85–90% pygidial length, short, low relief postaxial ridge; 4 axial rings, high convexity, nodes absent; terminal axial piece broadly rounded; axial furrows moderately shallow; axial ring furrows shallow to very shallow, uniform depth. Pleural regions well defined, sagittally elongate, triangular shaped; low to high convexity, downsloping; anterior pleural furrow broad, moderately shallow, extends to margin, curved slightly posterior; 3 additional pleural furrows, shallow to very shallow; interpleural furrows shallow to very shallow. Border narrow, width 10–15% pygidial length; slightly convex, level; border furrow moderately shallow, broad, deeper than pleural furrows.

Exoskeleton thin; smooth on all external and internal surfaces.

REMARKS. A diagnosis for *Kootenia quadriceps* has not been previously presented. The emended description is based primarily on the specimens found during this study. The type specimens from the Ute Limestone (Palmer, 1954) differ from specimens in this study by the less curvature of the anterior margin of the cranidia and the posterior most set of pygidial spines are shorter. Palmer's (1954:pl. 14, fig. 1) figured cranidium is smaller than the specimens from the Eldorado Formation, which may account for the less curvature of the anterior margin of the cranidium.

Kootenia quadriceps is similar to *K. dawsoni*, but differs in its pygidium having wider lateral bor-

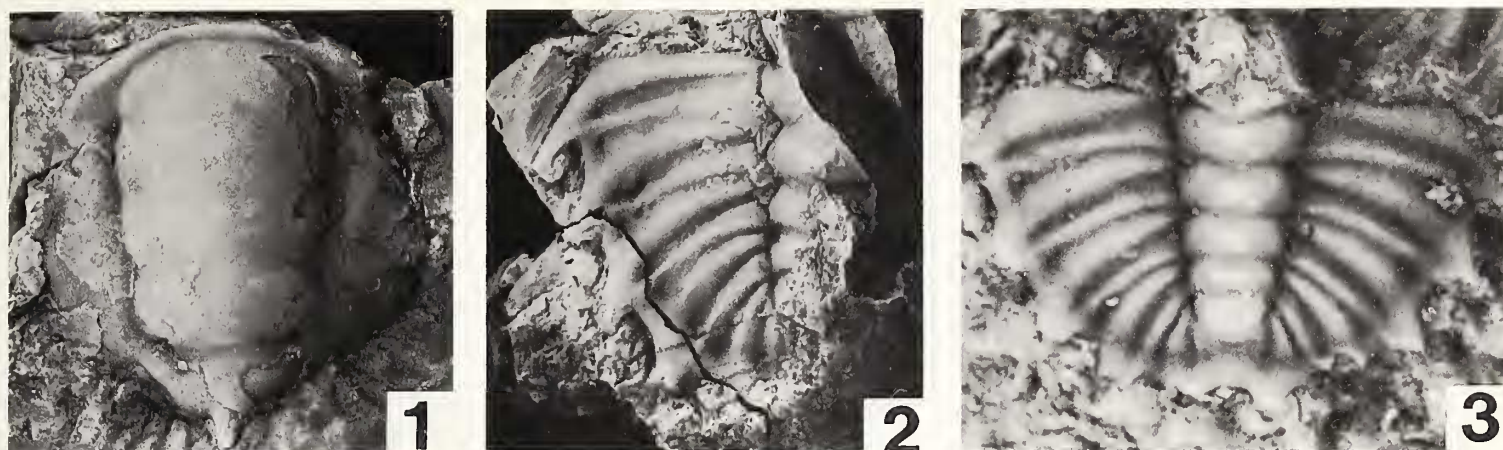


Figure 20. *Olenoides serratus* (Rominger). 1, Partial cranidium (LACMIP hypotype 11711), LACMIP locality 15592, partially exfoliated, $\times 3.6$. 2, Partial pygidium (LACMIP hypotype 11709), LACMIP locality 15517, exfoliated, $\times 1.8$. 3, Nearly complete pygidium (LACMIP hypotype 11710), LACMIP locality 15580, exfoliated, $\times 13.2$.

ders, no axial nodes or spines, and narrower-based border spines and its cranidium having concave axial furrows. *Kootenia quadriceps* differs from *K. cf. K. dawsoni* in having a pygidium with a wider border and wider-based border spines. *Kootenia burgessensis* Resser, 1942, is similar to *K. quadriceps* in its relatively wider pygidial border, but *K. quadriceps* differs in its less robust pygidial axis and narrower-based border spines. Pygidia of *K. germana* Resser, 1939b (Palmer and Halley, 1979:pl. 11, figs. 27–30), and *K. quadriceps* are very similar, but the glabella of *K. quadriceps* has concave axial furrows. *Kootenia quadriceps* is also similar to *K. ontoensis* but differs in having a less curved anterior border, a non-medially inflated glabella, wider (exsag.) and shorter (trans.) posterior area of fixigena, and no axial nodes on the pygidium.

HYPOTYPES. LACMIP 11695, 11698, 11699 from LACMIP locality 15526; LACMIP 11700–11702 from LACMIP locality 15535; LACMIP 11703, 11704 from LACMIP locality 15599.

OTHER MATERIAL. LACMIP locality 15526, 2 cranidia, 1 hypostoma, 1 librigena, 2 pygidia; LACMIP locality 15535, 8 cranidia, 1 hypostoma, 1 librigena, 1 pygidium; LACMIP locality 15599, 9 cranidia, 8 pygidia.

OCCURRENCE. *Ehmaniella* Biozone. Ute Limestone, Bear River Range, Utah (Palmer, 1954). *Altiocculus* Subzone, *Ehmaniella* Biozone. Trailer Limestone, Dugway Range, Utah. Eldorado Formation, northern Egan Range, Nevada.

Genus *Olenoides* Meek, 1877

TYPE SPECIES. *Paradoxides? nevadensis* Meek, 1877.

EMENDED DIAGNOSIS. Dorypygidae with cranidium with subquadrate to slightly expanded glabella with shallow lateral glabellar furrows; fixigenae convex, slightly downsloping. Pygidium with well-defined axis generally extending to border, 5–7 ring furrows; pleural fields crossed by 5–6 generally deep pleural and interpleural furrows, exsagittal width of anterior pleural bands increases lat-

erally; width of posterior pleural bands uniform; border poorly defined, generally 4 or more pairs of spines of equal length, evenly spaced along margin.

REMARKS. As noted in the discussions of *Dorypyge* and *Kootenia*, the pygidium of *Olenoides* has the anterior pleural bands expanding laterally and the posterior pleural bands uniform in width (Fig. 12). The shape and depth of the pygidial pleural and interpleural furrows can be used to distinguish *Olenoides* from *Dorypyge* and *Kootenia*.

Olenoides serratus (Rominger, 1887)

Figure 20

Ogygia serrata Rominger, 1887:13, pl. 1, figs. 2, 2a.

Olenoides serratus (Rominger), Rasetti, 1951:189–190, pl. 27, figs. 1–3 (see for complete synonymy); Whittington, 1975:101–134, pls. 1–24; Whittington, 1980:171–204, pls. 17–22; Whittington, 1992:pls. 13–18, 47–48, 50.

REMARKS. Incomplete cranidia and pygidia were found in the Swasey Limestone and stratigraphically equivalent units. These specimens resemble those illustrated by Rasetti (1951) but are too fragmentary or too small to be used for a detailed description.

HYPOTYPES. LACMIP 11709 from LACMIP locality 15517; LACMIP 11710 from LACMIP locality 15580; LACMIP 11711 from LACMIP locality 15592.

OCCURRENCE. *Ehmaniella* to *Altiocculus* subzones, *Ehmaniella* Biozone. Stephen Formation, Mount Stephen and Mount Field, British Columbia. Swasey Limestone, House Range, Utah. Eldorado Formation, northern Egan Range, Nevada. Pole Canyon Limestone, Member E, Patterson Pass.

Family Oryctocephalidae Beecher, 1897

Subfamily Oryctocephalinae Beecher, 1897

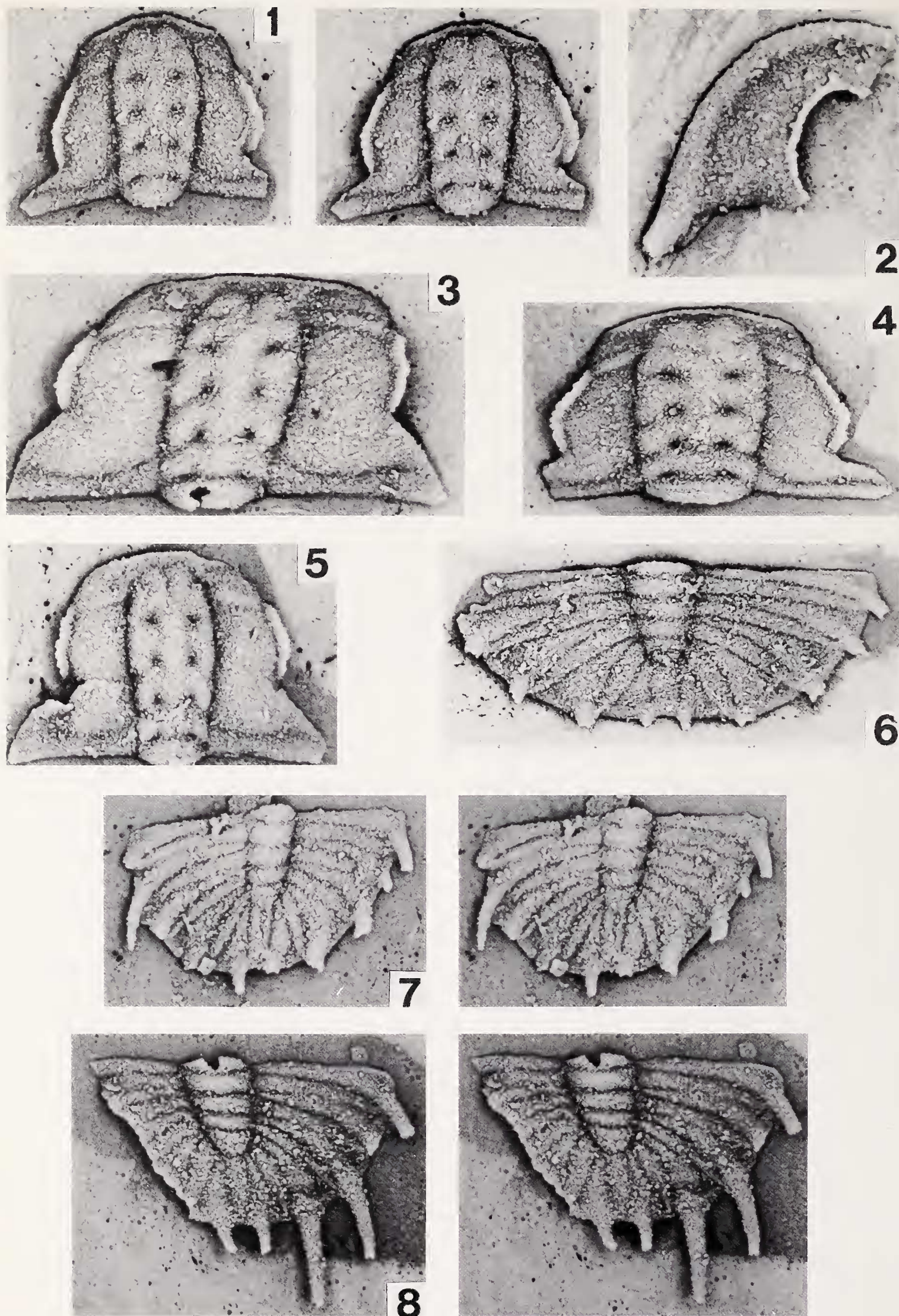


Figure 21. *Opsiosoryctocephalus ophis*, new genus and species. Silicified and distorted, LACMIP locality 15563, and coated with ammonium chloride. 1, Stereo pair of paratype cranidium (LACMIP 11714), $\times 12.6$. 2, Paratype free cheek (LACMIP 17725), $\times 17.6$. 3, Holotype cranidium (LACMIP 11712), $\times 15.5$. 4, Paratype cranidium (LACMIP 11713), $\times 12.9$. 5, Paratype cranidium (LACMIP 11715), $\times 12.8$. 6, Paratype pygidium (LACMIP 11723), $\times 11.4$. 7, Stereo pair of paratype pygidium (LACMIP 11720), $\times 12.6$. 8, Stereo pair of paratype pygidium (LACMIP 11721), $\times 12.2$.

Genus *Opsiosoryctocephalus*,
new genus

TYPE SPECIES. *Opsiosoryctocephalus ophis*, new species.

DIAGNOSIS. Oryctocephalinae with subtrapezoidal cranidium with glabella with medial sulcus, furrow pits connected with axial furrows and not connected with transglabellar furrow, and undulating axial furrows; posterior border furrow connecting with F1 furrows, occipital furrow connecting with posterior border. Pygidium with moderately deep pleural and interpleural furrows, 5 pairs of spines.

REMARKS. *Opsiosoryctocephalus* is erected on specimens that are structurally deformed. Although this is generally not a good practice, the characters displayed by the specimens are unique for the family.

Opsiosoryctocephalus is most similar to *Oryctocephalus* Walcott, 1886, *Oryctocephalites* Resser, 1939b, and *Oryctocephalina* Lermontova, 1940, in general appearance and is probably closely related. *Opsiosoryctocephalus* differs from the latter genera in having a medial glabellar sulcus, lateral glabellar furrows extending to the axial margin, sinuous axial furrows, and/or no transglabellar furrows. In Oryctocephalidae, most genera have one or two lateral glabellar furrows (the two anterior pairs) that reach the axial furrows; however, *Opsiosoryctocephalus*, *Tonkinella*, and *Sandoveria* Shergold, 1969, have more than two furrows that reach the axial furrows. Besides *O. ophis*, other species that illustrate the posterior border furrow of the cranidium to be strongly anteriorly directed adjacent to the axial furrows are *Oryctocephalus burgessensis* Resser, 1938b, and *Oryctocephalus reynoldsi* Reed, 1899 (also figured by Shergold, 1969). However, these species do not show the degree of joining of the posterior border furrow to the F1 furrow as in *Opsiosoryctocephalus*, but this may be the result of the effacement of lateral glabellar furrows in *O. burgessensis* and *O. reynoldsi*.

ETYMOLOGY. Greek, *opsios* = late and *Oryctocephalus*, late *Oryctocephalus*, referring to its higher stratigraphic position than to other genera of Oryctocephalidae in North America.

Opsiosoryctocephalus ophis,
new species

Figure 21

Oryctocephalidae, n. gen. et n. sp. Sundberg, 1991: 388, figs. 2.4, 2.5.

DIAGNOSIS. Same as genus.

DESCRIPTION. Cranidium small, length 1.8–2.8 mm; subtrapezoid, length approximately 60% width; low convexity (sag. and trans.); anterior margin slightly curved, anterior margin width approximately 60% cranial width; posterior margin, excluding occipital ring, straight. Facial sutures moderately convergent from ends of palpebral lobes to anterior margin; divergent moderately strong

posterior of palpebral lobes. Glabella elongate, length approximately 95% and width approximately 50% cranial length; glabella width approximately 30% cranial width; slightly expanding, width at anterior end approximately 115% glabellar width, anterior end width smaller than widest expansion at frontal lobe; low convexity (sag. and trans.); frontal lobe rounded, with medial sulcus, 4 lateral glabellar lobes. Axial furrows moderate depth, uniform depth, convex and sinuous around glabellar lobes; preglabellar furrow moderated depth, with medial sulcus forming 2 lobes, same depth as axial furrow; lateral glabellar furrows deep pits, with shallow to very shallow furrows extending to axial furrows, no transglabellar furrows, shallow furrows directed posteriorly or laterally. Occipital ring sagittal length approximately 15% glabellar length, not elevated above glabella, low convexity; no occipital spine; furrow straight, curved posteriorly laterally, intersecting with posterior margin, moderate depth, deep pits laterally; posterior margin slightly curved. Frontal area length approximately 6% cranial length. Preglabellar field absent. Anterior border slightly convex, upturned, uniform thickness, evenly curved. Anterior border furrow evenly curved, very shallow, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, approximately 65% glabellar width, moderately low convexity, level to slightly upsloping. Palpebral lobe narrow, width approximately 20% lobe length; long, length approximately 45% glabellar length; anterior margin located adjacent to approximately 15% glabellar length from anterior margin of frontal lobe; furrow shallow depth, narrow. Ocular ridge moderate strength, joins with glabella at F4 furrow, directly slightly posterolaterally from glabella at approximately 80° to axial trend. Posterior area of fixigena exsagittal width approximately 30% glabellar length; length approximately 65% glabella length; sharply terminated. Posterior border moderate convexity, widening laterally; border furrow moderately shallow, shallowing and wider laterally, curved posteriorly then anteriorly laterally, intersecting with F1 furrow.

Librigena small, length 2.0 mm; moderately wide, width approximately 50% length without spine; lateral margin curved moderately strong. Genal field slightly convex, width approximately 45% librigenal width. Border width approximately 20% librigenal width; moderately convex, level; lateral border furrow very shallow, very broad, shallowing posteriorly; posterior border furrow shallow, broad, very short. Genal spine long.

Hypostoma unknown.

Thoracic pleura sagittally elongate, low convexity (sag. and trans.); 2 pleural bands and 2 pleural furrows, subparallel to pleurae margins; anterior pleural band narrow; medial pleural band wide, distal end forming backward directed short spine; posterior pleural band narrowing laterally, relatively low relief, terminating before lateral margin.

Pygidium small, length 1.9–2.4 mm; subcircular, length approximately 50% width; anterior margin

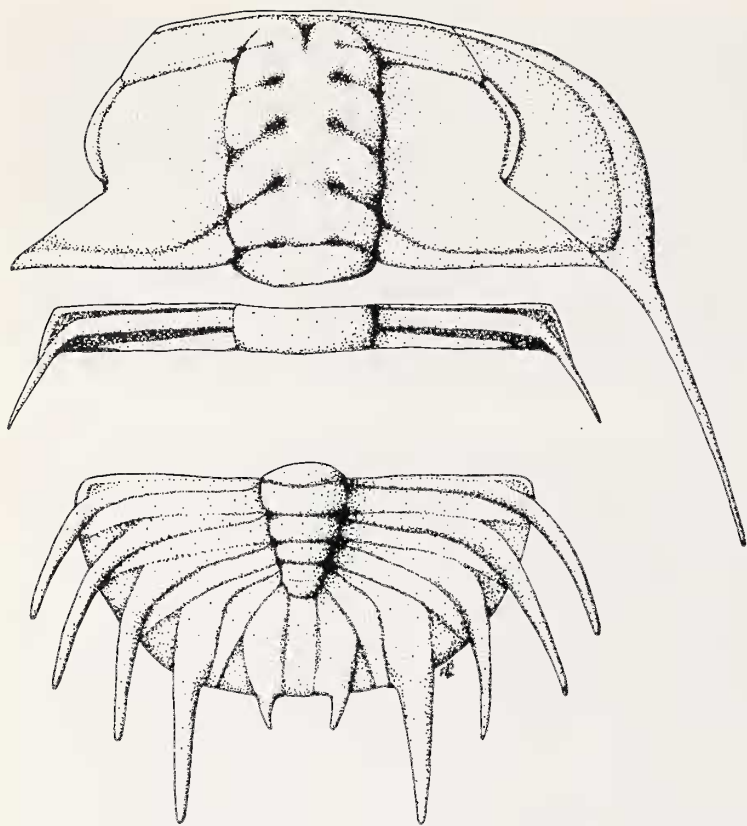


Figure 22. Reconstruction of *Opsiosoryctocephalus ophis*.

straight; lateral and posterior margins evenly curved; 5 pairs of spines, narrow, upturned, posterior pair small, anterior pairs moderate length to small? anteriorly; low convexity (sag. and trans.). Axis moderately tapered, axial mid-width approximately 80% axial anterior width, axial anterior width approximately 20% pygidial width; axial length approximately 60% pygidial length, no postaxial ridge; 3 possibly 4 axial rings, moderately low convexity, no axial nodes; terminal axial piece sharply round-

ed; axial furrows moderate depth; axial ring furrows moderately shallow, uniform depth. Pleural regions well defined, sagittally elongate, triangular shaped; low convexity, level; 5 pleural and interpleural furrows, narrow, moderate depth to shallow, shallowing posteriorly, extend to margin, curved slightly posterior to directed posteriorly at posterior end. Border narrow, poorly defined, approximately 18% pygidial length; border furrow absent.

Exoskeleton thin; smooth on all external and internal surfaces.

REMARKS. *Opsiosoryctocephalus ophis* is the only known species of the genus. Specimens are from the first meter of Lincoln Peak Shale overlying the Pole Canyon Limestone in the Snake Range. They are structurally deformed, coarsely silicified, and relatively abundant, although typically fragmented. Ratios given in the description are only approximate averages based on a few specimens (eight cranidia and five pygidia). The reconstruction of an undistorted cranidium, librigena, thoracic segment, and pygidium (Fig. 22) is based on several specimens that have been distorted in different directions.

Because of the stratigraphic position of *O. ophis*, the species normally would be considered as occurring in the *Ptychagnostus gibbus* Biozone. With the absence of faunas typical of the biozone and the association of the species with species typical of the upper Swasey Limestone (and stratigraphically equivalent units), *O. ophis* is considered as possibly occurring in the uppermost *Ptychagnostus praecurrens* Biozone (middle *Altiocculus* Subzone).

ETYMOLOGY. Greek, *ophis* = snake, named after the Snake Range.

HOLOTYPE. Cranidium (LACMIP 11712) from

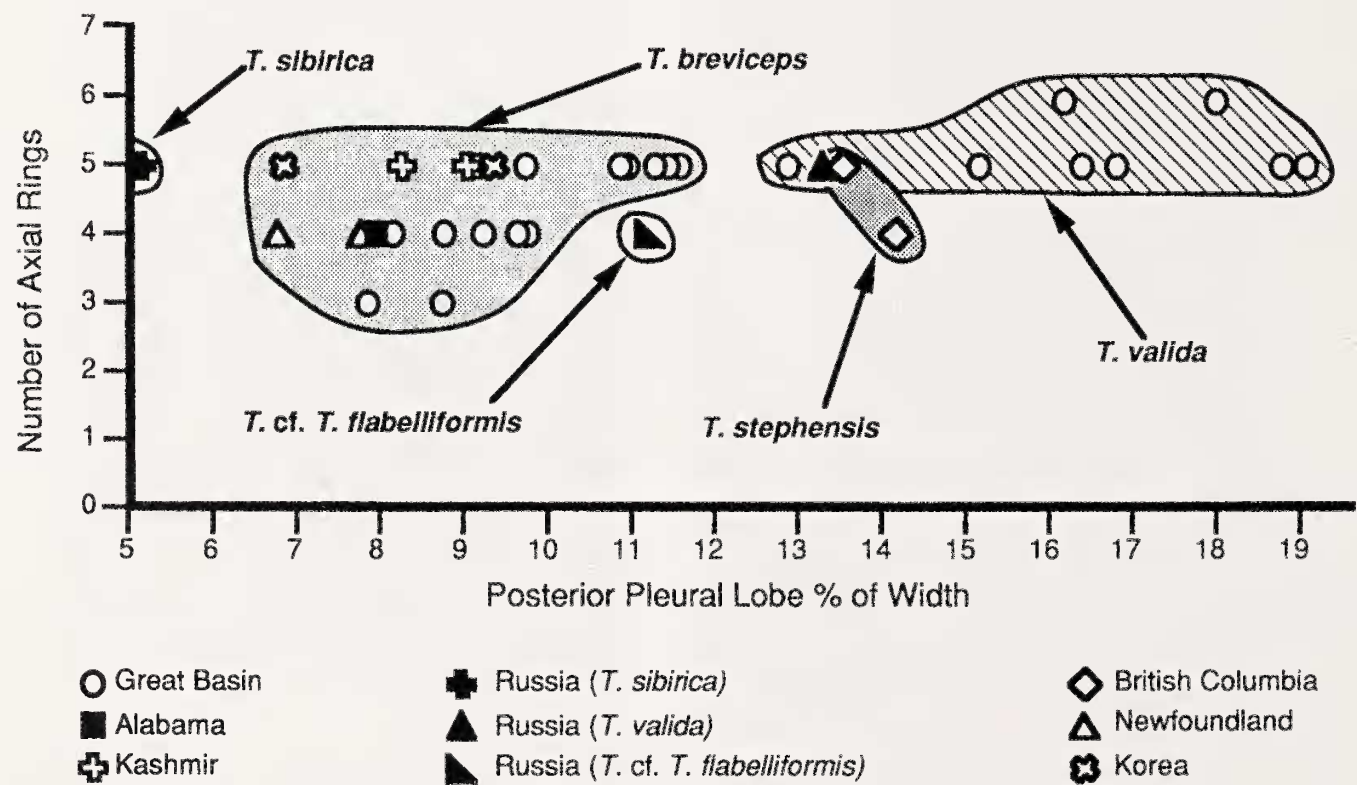


Figure 23. Distribution of *Tonkinella* species based on the number of axial rings and posterior pleural lobe width.

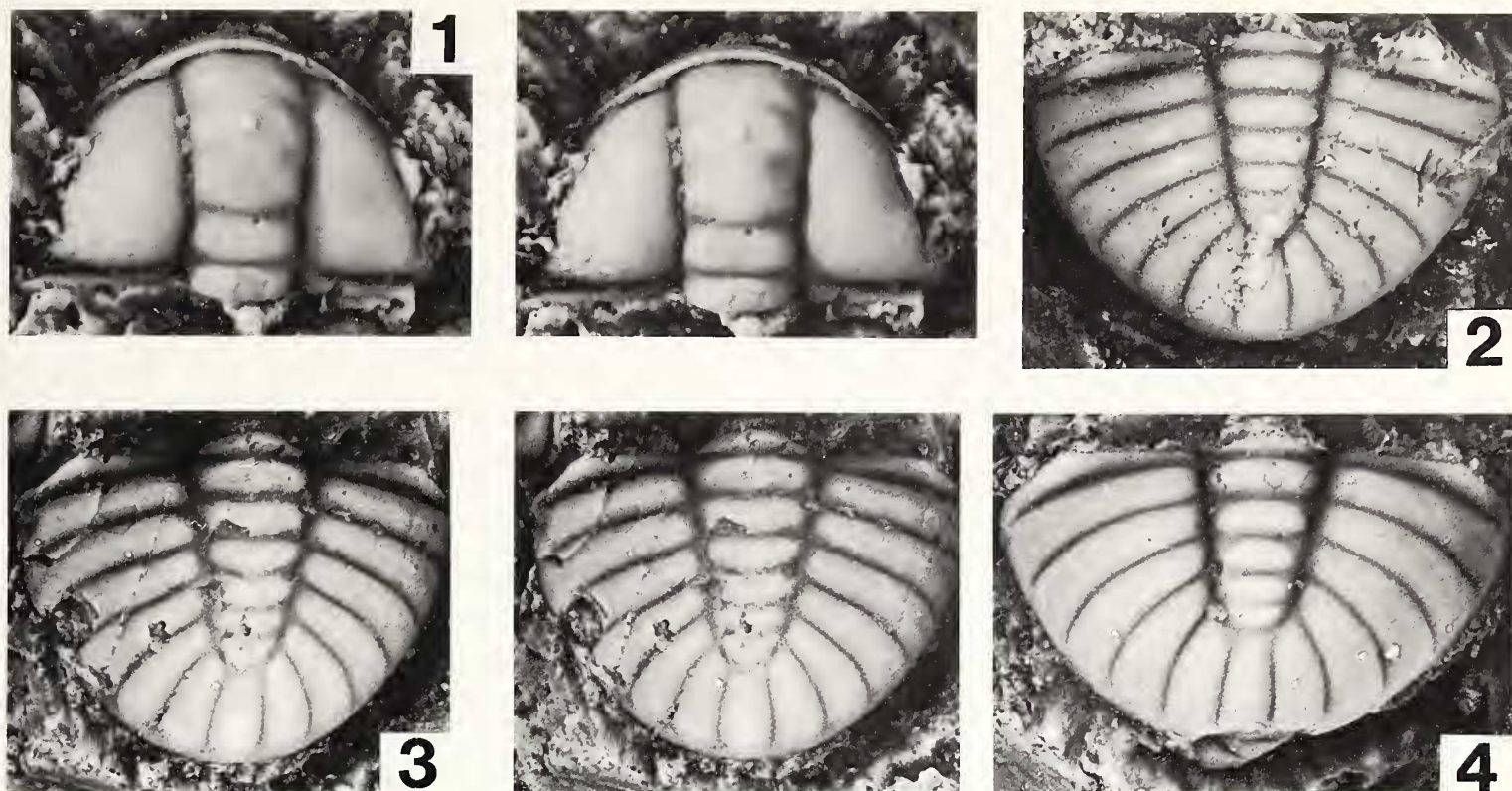


Figure 24. *Tonkinella breviceps* Kobayashi. 1, Stereo pair of cranidium (LACMIP hypotype 11728), LACMIP locality 15543, not exfoliated, $\times 7.5$. 2, Pygidium (LACMIP hypotype 11729), LACMIP locality 15543, exfoliated, $\times 8.3$. 3, Stereo pair of pygidium (LACMIP hypotype 11727), LACMIP locality 15517, not exfoliated, $\times 7.3$. 4, Pygidium (LACMIP hypotype 11726), LACMIP locality 15500, not exfoliated, $\times 7.3$.

the Lincoln Peak Shale, Snake Range, Nevada (LACMIP locality 15563).

PARATYPES. LACMIP 11713–11725 from LACMIP locality 15563.

OTHER MATERIAL. LACMIP locality 15563, several cranidia, librigenae, and pygidia.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Lincoln Peak Shale, Snake Range.

Subfamily Tonkinellinae Reed, 1934

Genus *Tonkinella* Mansuy, 1916

TYPE SPECIES. *Tonkinella flabelliformis* Mansuy, 1916.

DIAGNOSIS. Tonkinellinae with lateral glabellar furrows connecting with the axial furrows at the F2 and F3 positions.

REMARKS. Most species of *Tonkinella* are identified by their pygidial characters, primarily the number of axial rings and the relative transverse width of the posterior pleural lobe. Figure 23 illustrates the variation of these characters in *T. valida* (Great Basin and Russian specimens); *T. ex gr. flabelliformis* Mansuy of Tchernysheva, 1962; *T. sibirica* Tchernysheva, 1962; *T. stephensis* Kobayashi, 1935; *T. breviceps* (Great Basin, Canadian, and Asian specimens); and *T. appalachia* Resser, 1938a (= *T. breviceps*). Based on a limited number of specimens, four groups of *Tonkinella* pygidia can be recognized based on the relative width of the posterior pleural segment and the number of axial rings: (1) *T. sibirica* (approximately 5%, five axial rings),

(2) *T. breviceps*–*T. ex gr. flabelliformis* (6.8–11.5%, three to five axial rings), (3) *T. stephensis* (13.4–14.5%, four to five axial rings), and (4) *T. valida* (13.4–19.2%, five to six axial rings). Furthermore, *T. ex gr. flabelliformis* and *T. breviceps* can be differentiated based on the greater curvature of the pygidial anterior margin of the former and *T. stephensis* and *T. valida* can be differentiated based on cranidial features and minor pygidial features.

Tonkinella breviceps Kobayashi, 1934 Figure 24

Tonkinella breviceps Kobayashi, 1934:300–301, figs.

2–6; Kobayashi, 1935:150–151, pl. 15, figs. 6, 8–9.

Tonkinella appalachia Resser, 1938a:101, pl. 8, figs. 36–37.

Tonkinella kobayashi Resser, 1938b:43.

Tonkinella sp. Kindle, 1982:pl. 1.1, fig. 12.

Tonkinella khorbusuonkensis Solov'yev, 1989:60, pl. 7, fig. 9.

Tonkinella occidentalis Young and Ludvigsen (part), 1989:20, pl. 6, figs. 5–7, 11.

EMENDED DIAGNOSIS. *Tonkinella* with up-turned anterior border on cranidium. Pygidium with smooth margin, moderate to moderately shallow pleural furrows of uniform depth not reaching border, narrow posterior pleural segment, segment width 7–11.5% pygidial width, 3–5 axial rings.

EMENDED DESCRIPTION. Cranidium small, length 3.3–4.0 mm; subcircular, length 70–80% width; low convexity (sag. and trans.), height 30–40% width; anterior margin strongly curved; anterior margin width 65–75% cranidial width; poste-

rior margin, excluding occipital ring, straight. Facial sutures slightly convergent from ends of palpebral lobes to anterior margin; slightly divergent posterior of palpebral lobes. Glabella elongate, length 93–95% and width 45–50% cranial length; glabella width 30–35% cranial width; slightly expanding, width at anterior end 110–115% glabellar width; low convexity (sag. and trans.); frontal lobe slightly rounded laterally, flattened medially, 3 lateral glabellar lobes. Axial furrow moderately deep, shallowing anteriorly, slightly concave; preglabellar furrow moderately deep, slightly shallower than axial furrows; F1 glabellar furrow transglabellar, moderate depth laterally, extending to axial furrows, F2 and F3 lateral glabellar furrows shallow to very shallow, not connected with transglabellar furrows, extending to axial furrows; furrows directed laterally to slightly anteriorly. Occipital ring sagittal length 10–15% glabellar length, not elevated above glabella, low convexity; no occipital spine or node; furrow straight, moderate depth; posterior margin slightly curved. Frontal area length 5–7% cranial length. Preglabellar field absent. Anterior border flat, upturned, lying against or next to glabellar or fixigenae, thin, uniform thickness, evenly curved. Anterior border furrow evenly curved, very deep, deeper than axial furrows. Fixigena width, exclusive of palpebral lobe, 70–85% glabellar width, moderately low to moderate convexity, flat. Palpebral lobe moderately wide, width 25–35% lobe length; short, length 20–25% glabellar length; anterior margin located adjacent to 30–35% glabellar length from anterior margin of frontal lobe; furrow moderately deep, narrow. Ocular ridge weak, joins with glabella at anterior end next of preglabellar furrow, directed moderately posterolaterally from glabella at 70–75° to axial trend. Posterior area of fixigena exsagittal width 35–45% glabellar length; length 40–55% glabella length; sharply terminated?. Posterior border moderately convex, uniform width; border furrow deep, uniform depth, wider laterally, straight.

Librigena, hypostoma, and thorax unknown.

Pygidium small; length 2.5–4.0 mm; subcircular, length 55–65% width; anterior margin slightly curved posteriorly; lateral and posterior margins evenly curved; no spines; moderately high sagittal and low transverse convexity, height 25–30% width. Axis moderately tapered, axial mid-width 70–85% axial anterior width, axial anterior width 25–30% pygidial width; axial length 60–70% pygidial length, no postaxial ridge; 3–5 axial rings, moderate convexity, no axial nodes; terminal axial piece sharply rounded; axial furrows deep; axial ring furrows moderate and uniform depth. Pleural regions well defined, sagittally elongate, triangular shaped; low convexity, downsloping; 6 pairs of interpleural furrows, narrow, moderate depth to moderately shallow, uniform depth, extend almost to margin, curved slightly posterior to directed posteriorly at posterior end; posterior pleural segment 7–11.5% of width.

Border narrow, 1–5% pygidial length; border furrow absent.

Exoskeleton thin; pitted(?) on cranidia and/or smooth on all external and internal surfaces.

REMARKS. The species description is based primarily on Great Basin specimens. The type specimens of Kobayashi (1935) were not studied. The cranidia from the Great Basin differ from the single specimen described by Kobayashi (1935) in not possessing “punctae.” The illustration of the type cranidium is inadequate to determine whether or not punctae are present. In another description, Kobayashi (1934) did not comment on surface ornamentation because the exoskeleton had been “altered secondarily.” Kobayashi (1934) is referred to as the later paper even though it predates his 1935 paper because Kobayashi cited his 1935 paper in his 1934 paper. This suggests that the 1935 paper was accepted for publication first. Resser (1938b) assigned the name *T. kobayashi* for *T. breviceps* reported by Kobayashi (1935) from South Korea.

The pygidia from the Great Basin, Newfoundland (Kindle, 1982), Kashmir (Kobayashi, 1934), South Korea (Kobayashi, 1935), and Alabama (Resser, 1938a) show variation in the number of axial rings and the relative width of the median pleural lobe (Fig. 23). However, all of the pygidia from the various localities have shallow to moderately shallow pleural furrows, continuous smooth margin, and the same general shape. The cranidia from these collections, when present, are also very similar in morphology to one another. The pygidial and cranidial similarities of these specimens from the different regions provide the justification for assigning them to the same species. *Tonkinella khorbusuonkensis* Solov'yev, 1989, was based on only five cranidia from Siberia. The figured cranidia are identical to the cranidium figured here (Fig. 24.1); thus, *T. khorbusuonkensis* is placed into questionable synonymy with *T. breviceps* because the pygidium of the former species is not known.

The biostratigraphic range of *T. breviceps* in North America and Russia is restricted to the *Ehmaniella* Biozone. Resser (1938a) reported this species (= *T. appalachia*) from the Rogersville Shale, which is predominately *Ehmaniella* Biozone (Sundberg, 1989a). The specimens from the Great Basin are from the upper *Ehmaniella* and lower *Ptychagnostus gibbus* biozones. Kindle (1982) illustrated a *Tonkinella* pygidium from Newfoundland that is very similar to *T. breviceps* from the Great Basin, although the associated cranidium is similar to *T. valida*. *Tonkinella occidentalis* Young and Ludvigsen (1989) from Newfoundland is in part synonymous with *T. breviceps*. The specimens of Kindle (1982) and of Young and Ludvigsen (1989) are associated with fossils from the uppermost *Ehmaniella* and/or *Ptychagnostus gibbus* biozones. The specimens of Solov'yev (1989) from Siberia are associated with *Ptychagnostus gibbus*.

Tonkinella breviceps is most similar to *T. ste-*

phensis (type specimens illustrated by Rasetti, 1951: pl. 31, figs. 13–18) but differs in having a convex, raised anterior border on the cranidium and the pygidium having shallower pleural furrows that do not reach the margin, un-scalloped lateral and posterior margins, narrower posterior pleural segment, and three to five axial rings.

HYPOTYPES. LACMIP 11726 from LACMIP locality 15500; LACMIP 11727 from LACMIP locality 15517; LACMIP 11728, 11729 from LACMIP locality 15543.

OTHER MATERIAL. LACMIP locality 15495, 1 pygidium; LACMIP locality 15496, 9 pygidia; LACMIP locality 15499, 2 pygidia; LACMIP locality 15500, 8 pygidia; LACMIP locality 15517, 3 cranidia, 4 pygidia; LACMIP locality 15519, 1 cranidium, 2 pygidia; LACMIP locality 15528, 2 pygidia; LACMIP locality 15537, 1 cranidium; LACMIP locality 15540, 1 pygidium; LACMIP locality 15541, 1 cranidium, 2 pygidia; LACMIP locality 15543, 1 cranidium, 2 pygidia; LACMIP locality 15545, 2 pygidia; LACMIP locality 15547, 1 cranidium, 4 pygidia; LACMIP locality 15548, 6 pygidia; LACMIP locality 15563, several pygidia; LACMIP locality 15565, 1 cranidium, 4 pygidia; LACMIP locality 15569, 1 cranidium, 1 pygidium; LACMIP locality 15570, 2 cranidia, 2 pygidia; LACMIP locality 15571, 1 cranidium; LACMIP locality 15580, 2 cranidia, 6 pygidia; LACMIP locality 15581, 1 cranidium.

OCCURRENCE. *Ehmaniella* Biozone. Rogersville Shale, west of Montevallo, Alabama (Resser, 1938a). *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains and House Range, Utah. Trailer Limestone, Dugway Range, Utah. Pole Canyon Limestone, Lincoln Peak Formation and/or Patterson Pass Shale, Snake Range and Patterson Pass, Nevada. Uppermost *Ehmaniella* and/or *Ptychagnostus gibbus* biozones. Cow Head Group, Broom Point, Newfoundland, Canada (Kindle, 1982). Middle Cambrian, “*Olenoides*” biozone. Taiki Group, Neistsu, Kogen-do, South Korea (Kobayashi, 1935); Chuwa, Heian-nando, North Korea (Kobayashi, 1934). Middle Cambrian, probably *Ehmaniella* Biozone (based on the occurrence of *Oryctocephalus reynoldsi* Reed). Handawara Group, Kashmir (Kobayashi, 1934).

Tonkinella valida
Tchernysheva, 1962
Figure 25

Tonkinella valida Tchernysheva, 1962:30–32, pl. 3, figs. 1–3, not fig. 4.

Tonkinella sp. Kindle, 1982:pl. 1.1, fig. 8.

Tonkinella occidentalis Young and Ludvigsen (part), 1989:20, pl. 6, figs. 8–10.

EMENDED DIAGNOSIS. *Tonkinella* with cranidium with strongly posterolateral directed ocular ridges, slightly upturned anterior border, low convex frontal lobe, plectrum, and medial sulcus in frontal lobe. Pygidium with smooth margin, moderate to moderately shallow pleural furrows of uniform depth not reaching border, wide posterior

pleural segment (13–19% pygidial width), and 5–6 axial rings.

EMENDED DESCRIPTION. Cranidium moderate size, length 7.1 mm; rectangular, length approximately 65% width; low convexity (sag. and trans.), height approximately 30% width; anterior margin moderately curved, anterior margin width approximately 70% cranial width; posterior margin, excluding occipital ring, straight to slightly backswept. Facial sutures slightly convergent from ends of palpebral lobes to anterior margin; slightly divergent posterior of palpebral lobes. Glabella elongate, length approximately 95% and width approximately 65% cranial length; glabella width approximately 25% cranial width; slightly expanding, width at anterior end approximately 110% glabellar width; low convexity (sag. and trans.); frontal lobe slightly rounded laterally, flattened medially, medial sulcus, 4 lateral glabellar lobes. Axial furrows moderately deep, shallowing anteriorly, slightly concave; preglabellar furrow moderate depth, shallower than axial furrows; F1 glabellar furrow transglabellar, moderate depth laterally, shallowing medially, extending to axial furrows, F2, F3, and F4 lateral glabellar furrows shallow to very shallow, not connected with transglabellar furrows, extending to axial furrows; furrows directed laterally to anteriorly. Occipital ring sagittal length approximately 15% glabellar length, not elevated above glabella, low convexity; no occipital node; furrow straight, moderate depth; posterior margin slightly curved. Frontal area length approximately 5% cranial length. Preglabellar field absent. Anterior border convex, upturned, thin, uniform thickness, evenly curved. Anterior border furrow evenly curved, shallow, shallower than axial furrows. Plectrum well defined; posterior margins very slightly curved, beginning at anterolateral corners. Fixigena width, exclusive of palpebral lobe, approximately 115% glabellar width, low convexity, upsloping. Palpebral lobe moderately narrow, width approximately 15% lobe length; moderate length, length approximately 40% glabellar length; anterior margin located adjacent to approximately 40% glabellar length from anterior margin of frontal lobe; furrow moderately deep, narrow. Ocular ridge moderate strength, joins with glabella at L4 furrow, directed strongly posterolaterally from glabella at approximately at 65° to axial trend. Posterior area of fixigena exsagittal width approximately 20% glabellar length; length approximately 55% glabella length; sharply terminated? Posterior border moderately low convexity, uniform width; border furrow shallow, uniform depth, straight.

Librigena, hypostoma, and thorax unknown.

Pygidium small to moderate size, length 4.7–10.0 mm in length; outline subcircular, length 65–80% width; anterior margin straight; lateral and posterior margins evenly curved; no spines; moderately high sagittal and low transverse convexity, height 20–30% width. Axis moderately tapered, axial mid-

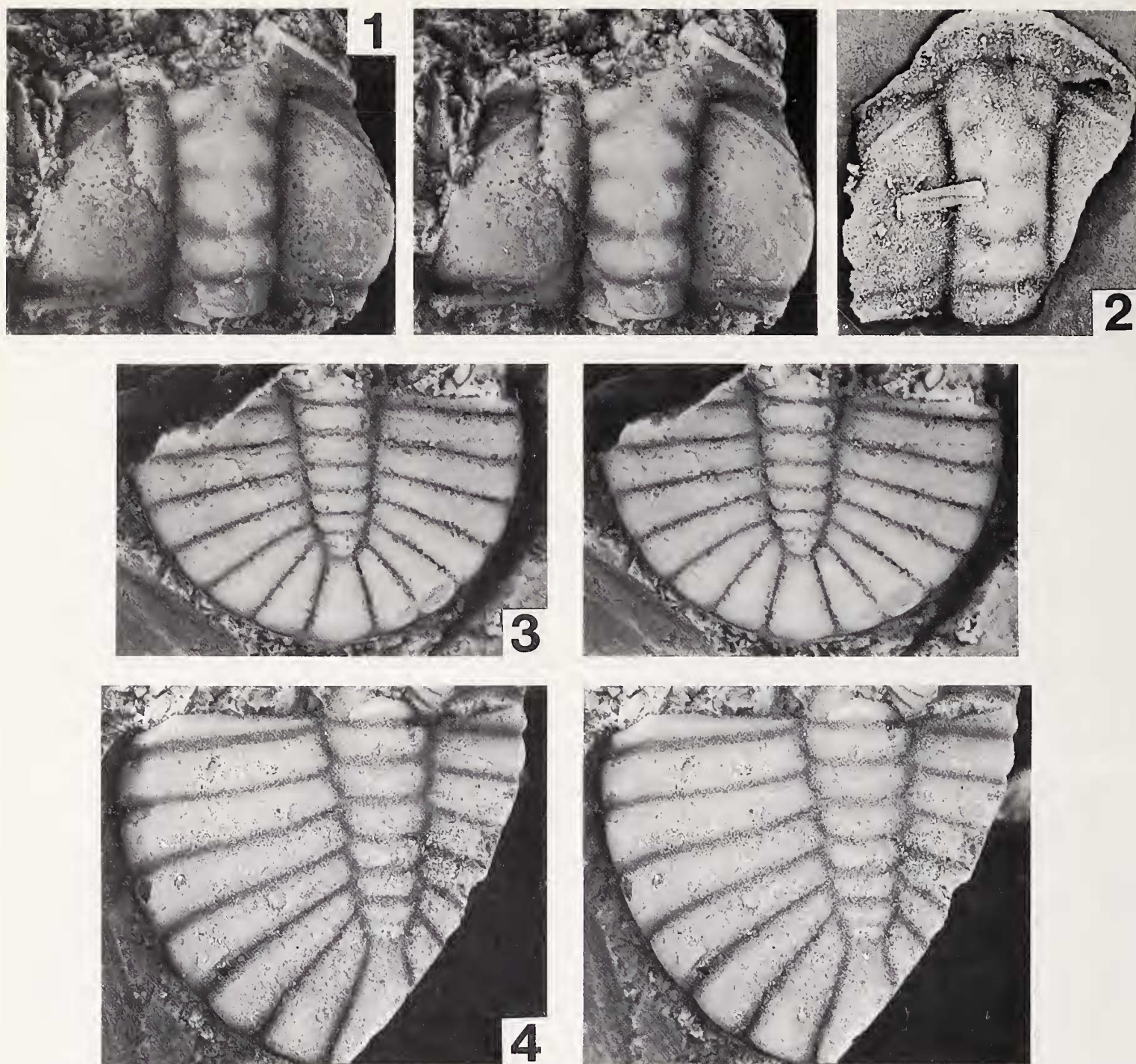


Figure 25. *Tonkinella valida* Tchernysheva. 1, Stereo pair of partial cranidium (LACMIP hypotype 11733), LACMIP locality 15580, mostly exfoliated, $\times 9.4$. 2, Distorted and silicified partial cranidium (LACMIP hypotype 11732), LACMIP locality 15563, coated with ammonium chloride, $\times 9.7$. 3, Stereo pair of pygidium (LACMIP hypotype 11731), LACMIP locality 15548, exfoliated, $\times 6.6$. 4, Stereo pair of partial, large pygidium (LACMIP hypotype 11703), LACMIP locality 15500, exfoliated, $\times 4.2$.

width 75–85% axial anterior width, axial anterior width 20–25% pygidial width; axial length 60–65% pygidial length, no postaxial ridge; 5–6 axial rings, moderate convexity, no axial nodes; terminal axial piece rounded; axial furrows moderate depth; axial ring furrows moderate and uniform depth. Pleural regions well defined, sagittally elongate, triangular shaped; low convexity, downsloping; 7 pairs of interpleural furrows, narrow, moderate depth to moderately shallow, uniform depth, extend almost to margin, curved slightly posterior to directed posteriorly at posterior end; posterior pleural segment wide, 13–19% of width. Border narrow, approximately 1% pygidial length.

Exoskeleton thin; smooth on external and internal surfaces.

REMARKS. The emended diagnosis and descriptions are based on the figured specimens of Tcher-

nysheva (1962) and the specimens collected for this study. The cranidium of *Tonkinella valida* is distinctive in its less convex frontal lobe, strongly posterolaterally directed ocular ridges, medial sulcus, and plectrum. Kindle (1982) and Young and Ludvigsen (1989) illustrated cranidia from Newfoundland very similar to *T. valida* from Russia and the Great Basin. These specimens are tentatively assigned to the species, although they have two transglabellar furrows instead of one. The pygidium of *T. valida* is similar to the type specimens of *T. stephensis* illustrated by Rasetti (1951) but differs in having an unscaloped margin and interpleural furrows not reaching the margin. The pygidium of *T. valida* is also similar to the pygidium of *T. breviceps* but has a wider posterior pleural segment and five to six axial rings (Fig. 23).

HYPOTYPES. LACMIP 11730 from LACMIP

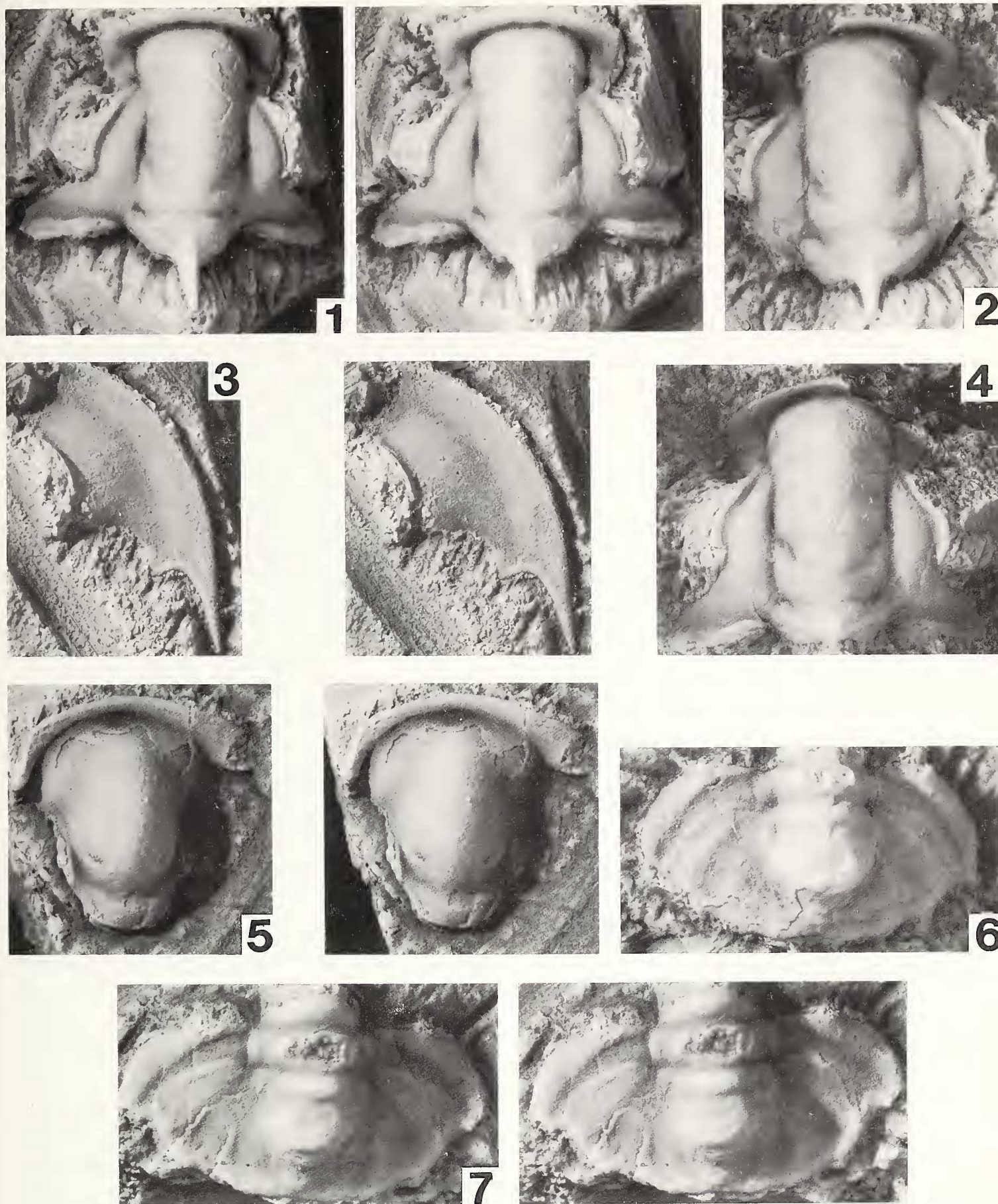


Figure 26. *Wenkchemnia? housensis*, new species, RC locality 375. 1, Stereo pair of holotype cranium (KUMIP 204758), partially exfoliated, $\times 5.7$. 2, Partial paratype cranium (KUMIP 204759), partially exfoliated, $\times 5.0$. 3, Stereo pair of paratype free cheek (KUMIP 204765), not exfoliated, $\times 6.4$. 4, Paratype cranium (KUMIP 204769) with very short occipital spine, partially exfoliated, $\times 5.0$. 5, Stereo pair of paratype hypostoma (KUMIP 204766), partially exfoliated, $\times 6.0$. 6, Paratype pygidium (KUMIP 204762), partially exfoliated, $\times 8.6$. 7, Stereo pair of paratype pygidium (KUMIP 204761), exfoliated, $\times 8.0$.

locality 15500; LACMIP 11731 from LACMIP locality 15548; LACMIP 11732 from LACMIP locality 15563; LACMIP 11733 from LACMIP locality 15580.

OTHER MATERIAL. LACMIP locality 15496, 1 pygidium; LACMIP locality 15497, 2 pygidia; LACMIP lo-

cality 15500, 3 pygidia; LACMIP locality 15518, 2 cranidia, 1 pygidium; LACMIP locality 15543, 1 cranium; LACMIP locality 15548, 3 cranidia, 11 pygidia; LACMIP locality 15563, few cranidia, several pygidia; LACMIP locality 15565, 1 cranium; LACMIP locality 15569, 2 pygidia; LACMIP locality 15570, 1 pygidium; LACMIP locality 15580, 1 cranium, 1 pygidium.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Trailer Limestone, Dugway Range, Utah. Swasey Limestone, Drum Mountains and House Range, Utah. Pole Canyon Limestone, Member E and/or Lincoln Peak Shale, Snake Range and Patterson Pass, Nevada. Uppermost *Ehmaniella* and/or *Ptychagnostus gibbus* biozones. Cow Head Group, Broom Point, Newfoundland, Canada (Kindle, 1982; Young and Ludvigsen, 1989). *Ehmaniella* Biozone? Russia (Tchernysheva, 1962).

Family Dolichometopidae
Walcott, 1916

Genus *Wenkchemnia* Rasetti, 1951

TYPE SPECIES. *Wenkchemnia walcotti* Rasetti, 1951.

EMENDED DIAGNOSIS. Micropygous Dolichometopidae with cranidia with anteriorly expanding glabella, shallow axial furrows, tapering posterior area of fixigenae, and relatively shorter palpebral lobes. Posterior thoracic segment not projecting adjacent to pygidium. Small, transversely elongate pygidium with poorly defined border furrow, less distinct interpleural furrows, and either complete margin or incipient spines.

REMARKS. Rasetti (1951:184) separated *Wenkchemnia* from *Bathyriscus* based on its shallower axial furrows, small transversely elongated pygidium, and less distinct interpleural furrows, and from *Poliella* Walcott, 1916, based on its tapering posterior area of fixigenae, shorter palpebral lobes, and the posterior thoracic segment not "enveloping" the pygidium. Robison (1976) suggested that *Wenkchemnia* may be synonymous with *Bathyriscus*. However, the absence of a well-defined pygidial border furrow and the smaller pygidial size warrant the separation of the two genera. The depths of the interpleural furrows and axial furrows are variable features in corynexochid genera and, used as the only criteria, they do not warrant the separation of two genera.

Wenkchemnia? *housensis*,
new species

Figure 26

DIAGNOSIS. *Wenkchemnia* with cranidium with exsagittally narrow posterior area of fixigena (20–30% glabellar length), slightly expanding glabella (105–110%), occipital spine or node. Pygidium with converging pleural and interpleural furrows, pygidial axial nodes, and pygidial margin with 3 incipient spines.

DESCRIPTION. Cranidium moderate size, length 6.1–8.7 mm; trapezoidal, length 75–80% width; moderate sagittal and low transverse convexity, height 35–40% width; anterior margin slightly curved, anterior margin width 60–65% cranial width; posterior margin, excluding occipital ring,

slightly backswept. Facial sutures moderately divergent from ends of palpebral lobes to anterior border; parallel across anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 90–95% and width 40–50% cranial length; glabella width 30–35% cranial width; parallel sided with expanding frontal lobe, width at anterior end 105–110% glabellar width; high sagittal and moderate transverse convexity; frontal lobe bluntly rounded, 4 lateral glabellar lobes. Axial furrows moderate depth, deeper adjacent to lobe L2, straight; preglabellar furrow deep, moderately curved; lateral glabellar furrows shallow to very shallow, F1 furrow shallow, directed posteriorly, F2 furrow straight, F3 and F4 furrows directed anteriorly. Occipital ring sagittal length 15–20% glabellar length, not elevated above glabella, moderately convex; very short to long, narrow occipital spine; furrow curved slightly anteriorly, deep pits laterally, uniform depth medially, shallow depth; posterior margin curved flattened medially. Frontal area length 5–10% cranial length. Preglabellar field absent. Anterior border convex, upturned, wider laterally, evenly curved. Anterior border furrow evenly curved, moderately deep, deeper than axial furrows. Fixigena width, exclusive of palpebral lobe, 35–45% glabellar width, low convexity, level. Palpebral lobe narrow, width 10–20% lobe length; moderate length, length 35–40% glabellar length; anterior margin located adjacent to 30–35% glabellar length from anterior margin of frontal lobe; furrow moderate depth, wide. Ocular ridge moderate strength, directed very strongly posterolaterally from glabella at 40–45° to axial trend. Posterior area of fixigena exsagittal width 25–30% glabellar length; length 40–45% glabella length; terminates moderately round. Posterior border moderately low, convex, slightly wider laterally; border furrow shallow, straight, shallows laterally.

Librigena moderate size, length 4.9–6.3 mm; moderately wide, width 50–55% length without spine; lateral margin moderately curved. Genal field slightly convex, width 50–55% librigena width. Border width 25–30% librigenal width; gently convex, upsloping; lateral border furrow shallow, broad, uniform depth; posterior border furrow very shallow, broad, uniform depth. Genal spine moderate length, 35–40% librigenal length.

Hypostoma fused with rostrum; moderate size, length 5.0 mm; subtriangular, length approximately 185% width, strong convexity (sag. and trans.), height approximately 45% width; anterior margin slightly curved; lateral margins cusped, converging; posterior margin straight. Median body strongly convex (sag. and trans.); egg shaped with widest dimension posteriorly; maculae forming pits. Posterior lobe narrow, low convexity; furrow moderately shallow. Anterior border not defined, fused with rostral plate; border furrow shallow, wide. Lateral border poorly defined anteriorly, narrow, well defined posteriorly; convex posteriorly, posterior wings

slightly projecting, deep border furrow. Posterior border narrow, approximately 15% hypostoma length, moderately convex; border furrow narrow, moderately shallow. Rostral plate strongly convex; narrow medially, approximately 10% hypostoma length, widening and upsloping laterally, approximately 20% hypostoma length, projecting laterally.

Thorax unknown.

Pygidium small, length 2.5–3.0 mm; transversely elongate, length 45–50% width; anterior margin strongly curved posteriorly; lateral margins slightly curved, scalloped, 4 pairs of incipient spines, anteriorly positioned spines most developed; posterior margin flattened; moderate convexity (sag. and trans.), height 25–35% width. Axis slightly tapered, axial mid-width 85–95% axial anterior width, axial anterior width 35–40% pygidial width; axial length 70–80% pygidial length, no postaxial ridge; 3 axial rings, high convexity, possible spine on L1, incipient spine on L2; terminal axial piece broadly rounded; axial furrows shallow; axial ring furrow L1 moderate depth, L2 and L3 shallow to very shallow, uniform depth. Pleural regions well defined, triangularly shaped; low convexity, slightly down-sloping; anterior pleural furrow narrow, moderately shallow, extends to margin, curved strongly posterior; 2 additional pleural furrows, very shallow; interpleural furrows moderately shallow to very shallow, joining with pleural furrows near margin. Border narrow, width 10–15% pygidial length; very slightly convex, upsloping; border furrow absent.

Exoskeleton thin; small, densely spaced pits covering cranidia and librigena on external surface, most prominent on librigena border, smooth on internal surface; hypostomata and pygidia smooth on external and internal surfaces.

REMARKS. The pygidium of *Wenkchemnia?* *housensis* probably has an incipient spine on the L1 axial ring. Specimens are always broken in this location, which may have resulted from the breaking off of a spine.

Wenkchemnia? *housensis* has a cranidium that is similar to other species of *Wenkchemnia*, but the pygidium differs in having incipient spines and non-parallel pleural and interpleural furrows, thus its questionable assignment to the genus. *Wenkchemnia?* *housensis* is also similar in its general morphology to several species of *Poliella* but differs in having a lower palpebral lobe/glabella ratio (35–40%), narrower palpebral lobes, and tapered posterior area of fixigenae. *Poliella* specimens generally have palpebral lobes ranging from 40 to 60% of glabellar length (based on *P. denticulata* Rasetti [1951], *P. prima* [Walcott, 1908a] [illustrated in Rasetti, 1951], and *P. lomataspis* Palmer [in Palmer and Halley, 1979]).

Wenkchemnia? *housensis* is most similar to *W. spinicollis* Rasetti, 1951, but differs in its less expanded glabella, four pairs of pygidial spines, three axial rings with spines or nodes, and non-parallel pleural and interpleural furrows.

ETYMOLOGY. Latinized, named after the House Range.

HOLOTYPE. Cranidium (KUMIP 204758) from the Dome Limestone, House Range, Utah (RC locality 375).

PARATYPES. KUMIP 204759–204769 from RC locality 375.

OTHER MATERIAL. RC locality 107, 1 cranidium, 1 pygidium; RC locality 211, 5 cranidia; RC locality 374, 5 cranidia, 4 pygidia, 2 librigenae; RC locality 375, 11 cranidia, 2 pygidia, 1 hypostoma, 4 librigenae; LACMIP locality 15503, cranidia and pygidia fragments.

OCCURRENCE. *Proehmaniella* Subzone, *Ehmaniella* Biozone, Dome Limestone. House Range, Utah.

Wenkchemnia swasensis, new species

Figure 27

DIAGNOSIS. *Wenkchemnia* with cranidium with exsagittally narrow posterior area of fixigenae (20–30% glabellar length), greatly expanded frontal lobe (140–155%), short occipital spine or node. Pygidium with upturned border, posteriorly directed pygidial field furrows, short axis, short spine on L1 axial ring.

DESCRIPTION. Cranidium moderate size, length 2.9–9.3 mm; trapezoidal, length 60–65% width; moderately low sagittal and low transverse convexity, height 20–35% width; anterior margin moderately curved, flattened medially, anterior margin width 50–55% cranial width; posterior margin, excluding occipital ring, straight to very slightly backswept. Facial sutures slightly divergent from ends of palpebral lobes to anterior border; parallel across anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 97–98% and width 45–50% cranial length; glabella width 25–30% cranial width; divergent sides with expanding frontal lobe, width at anterior end 140–155% glabellar width; moderate convexity (sag. and trans.); frontal lobe bluntly rounded, 4 lateral glabellar lobes. Axial furrows shallow to moderately deep, deeper adjacent to lobes L4 and L5, concave; preglabellar furrow moderately deep, moderately curved; lateral glabellar furrows shallow or very shallow, F1 furrow bifurcated, shallow, directed posteriorly, F2 furrow very shallow, directed laterally, F3 very shallow, directed anteriorly, F4 shallow, directed anteriorly. Occipital ring sagittal length 15–20% glabellar length, not elevated above glabella, moderately convex; short occipital spine or node; furrow curved slightly anterior, shallow, deeper laterally; posterior margin curved. Frontal area length 2–3% cranial length. Preglabellar field absent. Anterior border strongly convex, upsloping, wider laterally?, evenly curved. Anterior border furrow evenly curved, shallow medially, moderately

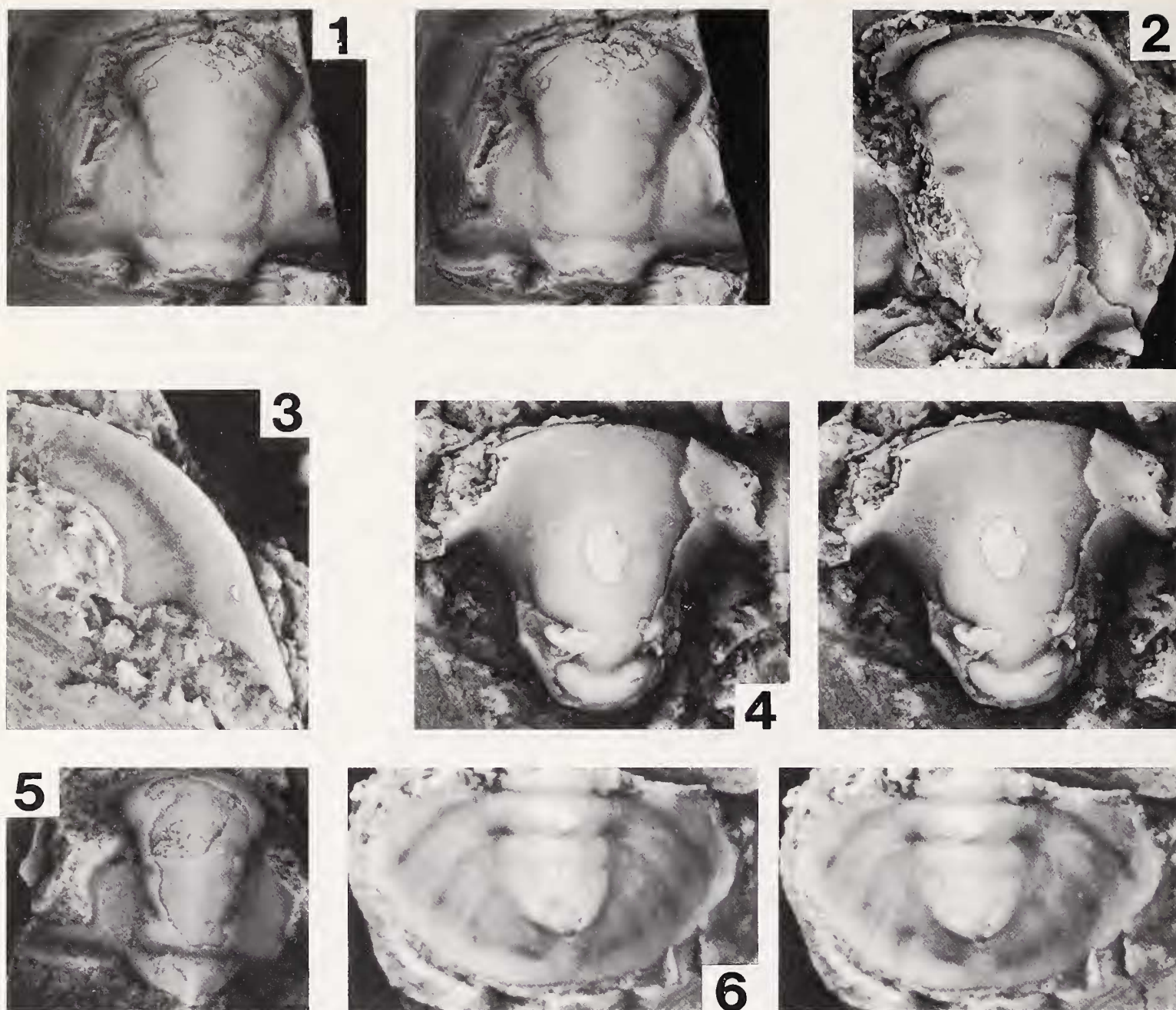


Figure 27. *Wenkchemnia swasensis*, new species. 1, Stereo pair of holotype cranium (LACMIP 11735), LACMIP locality 15477, exfoliated, $\times 3.0$. 2, Partial paratype cranium (LACMIP 11738), LACMIP locality 15482, mostly exfoliated, $\times 4.3$. 3, Paratype free cheek (LACMIP 11743), LACMIP locality 15482, not exfoliated, $\times 12.9$. 4, Stereo pair of paratype hypostoma (LACMIP 11744), LACMIP locality 15482, most exfoliated, $\times 12.1$. 5, Small cranium (LACMIP 11737), LACMIP locality 15484, partially exfoliated, $\times 9.2$. 6, Stereo pair of pygidium (LACMIP 11739), LACMIP locality 15482, not exfoliated, $\times 6.1$.

deep, laterally as deep as or deeper than axial furrows. Fixigena width, exclusive of palpebral lobe, 45–50% glabellar width, low convexity, level. Palpebral lobe narrow, width 15–20% lobe length; moderate length, length 30–35% glabellar length; anterior margin located adjacent to 30–40% glabellar length from anterior margin of frontal lobe; furrow shallow, wide. Ocular ridge short, moderate strength, directed very strongly posterolaterally from glabella at 45–50° to axial trend. Posterior area of fixigena exsagittal width 20–30% glabellar length; length 45–50% glabella length; terminates moderately round. Posterior border moderately low, convex, wider laterally; border furrow shallow, straight, shallows laterally.

Librigena small to moderate size, length 2.6 mm; moderate width, width 50–55% length without spine; lateral margin gently curved. Genal field slightly convex, upsloping, width 40–45% librigenal width. Border width 30–35% librigenal width; gently convex, level; lateral border furrow shallow,

moderate width, uniform depth; posterior border absent. Genal spine moderately short, 35–40% librigenal length.

Hypostoma fused with rostrum; small, length 2.1–3.8 mm; subtriangular, length 155–165% width, strong convexity (sag. and trans.), height 45–50% width; anterior margin moderately curved; lateral margins cusped, converging; posterior margin slightly curved. Median body strongly convex transversely, moderately convex sagittally; undifferentiated from rostrum; suboval shaped; maculae forming pits. Posterior lobe narrow, low convexity; furrow moderately shallow. Anterior border not defined, fused with rostral plate. Lateral borders undefined anteriorly; narrow, approximately 10% hypostoma width, well defined posteriorly; convex posteriorly, posterior wings slightly projecting, deep border furrow. Posterior border narrow, approximately 2% hypostoma length, moderately convex; border furrow narrow, moderately shallow. Rostral plate moderately convex; undifferentiated from me-

dian body, widening and upsloping laterally, 5–10% hypostoma length, projecting posterolateral.

Thorax unknown.

Pygidium small, length 1.7–2.9 mm; transversely elongate, length 50–55% width; anterior margin slightly curved posteriorly; lateral margins slightly curved to flattened; posterior straight to slightly curved; moderate convexity (sag. and trans.), height 20–25% width. Axis moderately tapered, axial mid-width 70–85% axial anterior width, axial anterior width 35–40% pygidial width; axial length 70–80% pygidial length, low postaxial ridge; 2–3 axial rings, high convexity, node on L1; terminal axial piece broadly rounded; axial furrows shallow; axial ring furrow L1 moderate depth, L2 and L3 shallow to very shallow, uniform depth. Pleural regions well defined, sagittally elongate, triangularly shaped; low convexity, downsloping; anterior pleural furrow narrow, shallow, extends nearly to margin, curved strongly posterior; 2 additional pleural furrows, very shallow; interpleural furrows very shallow, parallel to pleural furrows. Border narrow, width 5–10% pygidial length; slightly to moderately concave, slightly upsloping; border furrow very shallow.

Exoskeleton thin; smooth on external and internal surfaces.

REMARKS. *Wenkchemnia swasensis* differs from all other species of *Wenkchemnia* by its greatly expanded frontal lobe, shorter pygidial axis, pygidial spine, and strongly posteriorly directed pleural and interpleural furrows. *Wenkchemnia swasensis* is the youngest known species of the genus (middle *Ehmaniella* Biozone). Other known species are from the *Wenkchemnia*–*Stephenaspis* Biozone (early Middle Cambrian, Rasetti, 1951).

ETYMOLOGY. Latinized, named after the Swasey Limestone.

HOLOTYPE. Cranidium (LACMIP 11735) from the Swasey Limestone, Drum Mountains, Utah (LACMIP locality 15477).

PARATYPES. LACMIP 11736 from LACMIP locality 15477; LACMIP 11737 from LACMIP locality 15484; LACMIP 11738–11745 from LACMIP locality 15482.

OTHER MATERIAL. LACMIP locality 15476, 1 pygidium; LACMIP locality 15477, 1 pygidium; LACMIP locality 15478, 1 pygidium; LACMIP locality 15482, 10 cranidia, 8 pygidia, 1 hypostoma, 4 librigenae; LACMIP locality 15484, 5 cranidia, 2 pygidia, 2 hypostomata, 2 librigenae; LACMIP locality 15485, 1 cranidium, 1 pygidium, 1 librigena; LACMIP locality 15486, 3 cranidia, 3 pygidia, 1 hypostoma, 5 librigenae.

OCCURRENCE. *Ehmaniella* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains, Utah.

Family Zacanthoididae

Swannerton, 1915

Genus *Parkaspis* Rasetti, 1951

TYPE SPECIES. *Parkaspis endecamera* Rasetti, 1951.

EMENDED DIAGNOSIS. Zacanthoididae with cranidia with expanding glabella, preglabellar field absent, anterior border present, long, narrow, moderately curved palpebral lobes terminating opposite preoccipital lobe, facial sutures widely divergent anterior of palpebral lobes. Thoracic axial lobe not as wide (trans.) as pleural lobes exclusive of spines. Small, transversely elongate pygidium with axial lobe 40% or greater of pygidial width, pleural furrows moderate depth, border furrow indistinct, 4–6 pairs of posteriorly directed, rounded spines on posterior margin.

REMARKS. The diagnosis is slightly modified from Young and Ludvigsen (1989) to include axial width, pygidial axial width, and number of pygidial spines, which provides a more complete comparison to other Zacanthoididae.

Young and Ludvigsen (1989) placed *Parkaspis* into Zacanthoididae instead of Dolichometopidae as proposed by Rasetti (1951) based on the presence of a spinose pygidium and distinct metafixigenal spine.

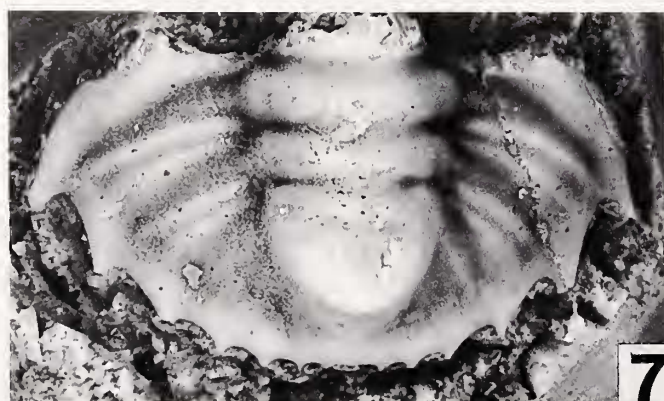
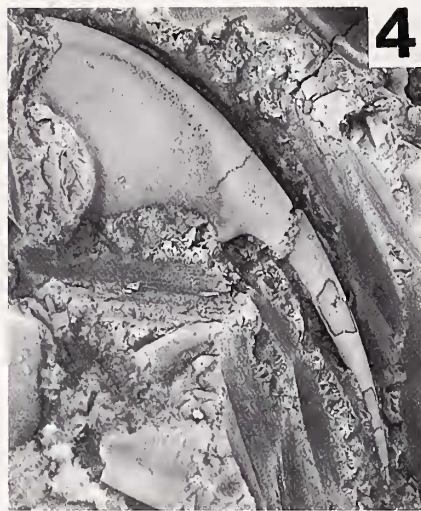
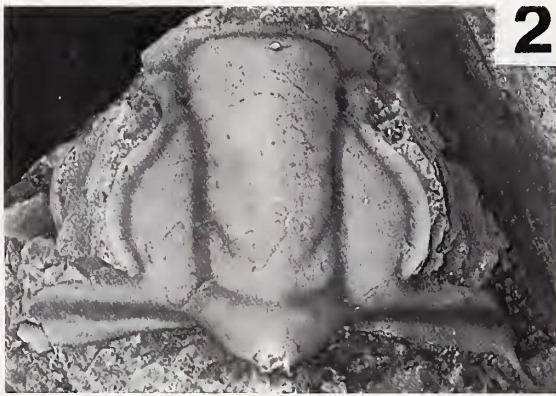
Parkaspis drumensis, new species

Figure 28

Parkaspis, n. sp. Sundberg, 1991:388, figs. 2.11, 2.12.

DIAGNOSIS. *Parkaspis* with cranidium with slightly expanding frontal lobe (110–120%), non-recurved posterior area of fixigenae, convex anterior border. Pygidium with short sagittal length (50–60% width), moderately tapering axis, no axial nodes, short pygidial spines. Smooth exoskeleton.

DESCRIPTION. Cranidium moderate size to large, length 7.2–14.0 mm; trapezoidal, length 55–65% width; moderate sagittal and low transverse convexity, height 25–35% width; anterior margin straight, anterior margin width 45–55% cranidial width; posterior margin, excluding occipital ring, straight to very slightly backswept. Facial sutures slightly divergent from ends of palpebral lobes to anterior border furrow; moderately convergent across anterior border; very strongly divergent posterior of palpebral lobes. Glabella elongate, length 95–98% and width 40–50% cranidial length; glabella width 25–30% cranidial width; parallel sides with expanding frontal lobe, width at anterior end 110–120% glabellar width; low convexity (sag. and trans.); frontal lobe bluntly rounded, 4 lateral glabellar lobes. Axial furrows shallow to moderate depth, shallow adjacent to lobe L3, slightly concave; preglabellar furrow moderately deep and straightly to slightly curved; lateral glabellar furrows shallow to very shallow, F1 furrow shallow, directed posteriorly, F2 furrow very shallow, directed slightly posteriorly, F3 very shallow, directed slightly anteriorly, F4 shallow, directed anteriorly. Occipital ring sagittal length 15–20% glabellar length, not elevated above glabella, moderately convex; short occipital spine; furrow slightly curved



posteriorly, shallow, uniform depth; posterior margin curved. Frontal area length 2–6% cranial length. Preglabellar field absent. Anterior border moderately convex, upsloping, wider laterally, straight. Anterior border furrow straight medially, curved around lateral sides of frontal lobe, moderate depth to moderately deep, deeper than axial furrows; furrow straight, moderately shallow lateral of glabella. Fixigena width, exclusive of palpebral lobe, 50–65% glabellar width, low convexity, level. Palpebral lobe narrow, width 10–15% lobe length; long, length 45–50% glabellar length; anterior margin located adjacent to 25–30% glabellar length from anterior margin of frontal lobe; furrow shallow, wide. Ocular ridge short, moderately weak, directed very strongly posterolaterally from glabella at 45–50° to axial trend. Posterior area of fixigena exsagittal width 15–20% glabellar length; length 55–65% glabella length; sharply terminated; short metafixigenal spine. Posterior border moderately convex, wider laterally; border furrow deep, straight, shallowing laterally; shallow secondary furrow on border paralleling primary furrow.

Librigena moderate size to large, length 9.1–10.5 mm; wide, width 65–70% length without spine; lateral margin moderately curved. Genal field slightly convex, width 55–60% librigenal width. Border width 10–15% librigenal width; moderately convex, downsloping; lateral border furrow moderately shallow, uniform depth; posterior border furrow short, shallow, broad, uniform depth. Genal spine long, 35–40% librigenal length.

Hypostoma fused with rostrum; small, length 3.9 mm; subtriangular, length approximately 155% width, strong convexity (sag. and trans.), height approximately 55% width; anterior margin slightly curved; lateral margins cusped, converging; posterior margin straight. Median body strongly convex (sag. and trans.); suboval shaped; maculae forming pits. Posterior lobe narrow, low convexity; furrow moderately shallow. Anterior border not defined, fused with rostral plate; border furrow shallow, wide. Lateral borders poorly defined anteriorly, narrow, approximately 10% hypostoma width; well defined posteriorly; convex posteriorly, posterior wings slightly projecting, deep border furrow. Posterior border narrow, approximately 2% hypostoma length, moderately convex; border fur-

row narrow, moderately shallow. Rostral plate strongly convex; narrow medially, approximately 5% hypostoma length, widening and upsloping laterally, approximately 20% hypostoma length, projecting laterally.

Number of thoracic pleura unknown. Pleura long, narrow, pleural furrow deep, terminates in short spine directed posteriorly.

Pygidium small, length 2.8–5.3 mm; transversely elongate, length 50–60% width; anterior margin strongly curved posteriorly; lateral margins moderately curved; posterior moderately to strongly curved, typically 6 pairs of broad-based spines, anterior spines most developed and longest, more posterior spines progressively shorter, posterior most pairs very small; low convexity (sag. and trans.), height 25–30% width. Axis moderately tapered, axial mid-width 75–85% axial anterior width, axial anterior width 40–45% pygidial width; axial length 65–70% pygidial length, no postaxial ridge; 3 axial rings, high convexity, no axial nodes; terminal axial piece strongly rounded; axial furrows shallow; axial ring furrows L1 and L2 moderately shallow; L3 very shallow, shallowing medially. Pleural regions well defined, slightly to moderately sagittally elongate, triangularly shaped; very low convexity, slightly downsloping; anterior pleural furrow narrow, deep, extends nearly to margin, straight to slightly curved, directed posteriorly; 2–3 additional pleural furrows, deep to very shallow; interpleural furrows very shallow to absent, parallel to pleural furrows near margin. Border narrow, width 10–15% pygidial length; slightly concave, level; border furrow very shallow.

Exoskeleton thin; smooth on external and internal surfaces.

REMARKS. Some pygidia of *Parkaspis drumensis* have higher length/width ratios than most specimens of the species and only 3–4 pairs of spines instead of 6 pairs. However, the other pygidial characters of these specimens and all of the cranial characters of the associated specimens are similar to other specimens of *P. drumensis*. Because of these similarities, the specimens with 3–4 pairs of spines are included in *P. drumensis*.

Parkaspis drumensis is most similar to *P. endecamera*, but differs in having a narrower frontal lobe, smooth exoskeleton, sagittally shorter pygidia, tapering pygidial axis, and abrupt termination of

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Figure 28. *Parkaspis drumensis*, new species. 1, Stereo pair of paratype cranidium (LACMIP 11752), LACMIP locality 15517, partially exfoliated, $\times 3.0$. 2, Stereo pair of holotype cranidium (LACMIP 11749), LACMIP locality 15500, partially exfoliated, $\times 3.4$. 3, Paratype hypostoma (LACMIP 11747), LACMIP locality 15500, not exfoliated, $\times 9.1$. 4, Paratype free cheek (LACMIP 11757), LACMIP locality 15543, not exfoliated, $\times 2.4$. 5, Paratype pygidium (LACMIP 11760) with fewer spines, LACMIP locality 15496, exfoliated, $\times 6.1$. 6, Stereo pair of paratype pygidium (LACMIP 11759), LACMIP locality 15495, partially exfoliated, $\times 6.3$. 7, Stereo pair of paratype pygidium (LACMIP 11754), LACMIP locality 15544, exfoliated, $\times 5.3$.

pleura. The type specimens of *P. endecamera* is slightly compressed, thus the width of the frontal lobe and the sagittal length of the pygidium may have been increased through compaction. *Parkaspis drumensis* is also similar to *P. decamera* Rasetti, 1951, but the poor preservation of the single known specimen of *P. decamera* prevents an accurate comparison of the two species. *Parkaspis drumensis* differs from *P. caboti* Young and Ludvigsen, 1989, in having a pygidium that is wider, less triangular in shape, and with shorter pygidial spines, and a cranidium with non-recurved posterior area of fixigenae and a convex anterior border.

ETYMOLOGY. Latinized, named after the Drum Mountains.

HOLOTYPE. Cranidium (LACMIP 11749) from the Swasey Limestone, Drum Mountains, Utah (LACMIP locality 15500).

PARATYPES. LACMIP 11746–11748, 11758 from LACMIP locality 15500; LACMIP 11750–11753 from LACMIP locality 15517; LACMIP 11754–11756 from LACMIP locality 15544; LACMIP 11757 from LACMIP locality 15543; LACMIP 11759 from LACMIP locality 15495; LACMIP 11760 from LACMIP locality 15496.

OTHER MATERIAL. LACMIP locality 15495, 4 cranidia, 4 pygidia, 2 hypostomata; LACMIP locality 15496, 28 cranidia, 10 pygidia, 5 hypostomata, 11 librigenae; LACMIP locality 15497, 3 cranidia; LACMIP locality 15498, 2 cranidia, 2 pygidia; LACMIP locality 15499, 1 cranidium, 6 pygidia; LACMIP locality 15500, 17 cranidia, 2 pygidia; LACMIP locality 15516, 1 cranidium; LACMIP locality 15517, 18 cranidia, 4 pygidia; LACMIP locality 15519, 6 cranidia, 1 pygidium; LACMIP locality 15537, 8 cranidia, 2 pygidia; LACMIP locality 15538, 4 cranidia, 3 pygidia; LACMIP locality 15540, 3 cranidia, 3 pygidia; LACMIP locality 15541, 5 cranidia; LACMIP locality 15542, 6 cranidia; LACMIP locality 15543, 25 cranidia, 16 pygidia; LACMIP locality 15544, 21 cranidia, 8 pygidia; LACMIP locality 15545, 30 cranidia, 5 pygidia; LACMIP locality 15547, 34 cranidia, 13 pygidia; LACMIP locality 15548, 51 cranidia, 25 pygidia; LACMIP locality 15564, 5 cranidia, 2 pygidia; LACMIP locality 15565, 9 cranidia, 3 pygidia; LACMIP locality 15567, 9 cranidia, 1 pygidium; LACMIP locality 15568, 44 cranidia, 7 pygidia; LACMIP locality 15569, 12 cranidia, 3 pygidia; LACMIP locality 15570, 16 cranidia, 2 pygidia; LACMIP locality 15571, 1 pygidium, 1 librigena; LACMIP locality 15580, 3 cranidia, 4 pygidia, 4 librigenae.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains and House Range, Utah. Trailer Limestone, Dugway Range, Utah. Pole Canyon Formation, Member E, Snake Range and Patterson Pass, Nevada.

Genus *Zacanthoides* Walcott, 1888

TYPE SPECIES. *Embolimus spinosa* Rominger, 1887.

DIAGNOSIS. Zacanthoididae with cranidia with slightly expanding glabella, preglabellar field and anterior border present, long, narrow, strongly curved palpebral lobes terminating opposite preoc-

cipital lobes, facial sutures widely divergent anterior of palpebral lobes. Thoracic axial lobe as wide or wider than pleural lobes exclusive of spines. Pygidium with axial lobe 33% or greater of pygidial width, pleural furrows shallow, border furrow indistinct, 3 or more pairs of posteriorly directed, flat spines on posterior margin.

REMARKS. The above diagnosis is derived from Palmer (1954) and Young and Ludvigsen (1989). Palmer (1954) has given a complete description of the genus and discussion of the type species.

Zacanthoides divergens

Rasetti, 1951 (s.l.)

Figure 29

Zacanthoides divergens Rasetti, 1951:146–147, pl. 32, figs. 8–10.

Zacanthoides, n. sp. Sundberg, 1991:388, fig. 2.9.

EMENDED DIAGNOSIS. *Zacanthoides* with cranidium with strongly divergent anterior facial sutures, wide frontal area (10–25% cranidial length) with moderately well-defined plectrum. Pygidium subrectangular with 4 short, flat spines of unequal length, and granules on pleural lobes.

EMENDED DESCRIPTION. Cranidium small to moderate size, length 2.5–6.1 mm; hourglass shape; moderately high sagittal and low transverse convexity; anterior margin moderately curved, posterior margin not preserved. Facial sutures strongly divergent from ends of palpebral lobes to anterior border; moderately divergent across anterior border; probably strongly divergent posterior of palpebral lobes. Glabella elongate, length 75–80% and width 35–40% cranidial length; sides slightly divergent with expanding frontal lobe, width at anterior end 105–115% glabellar width; high to low sagittal and low transverse convexity; anterior end bluntly rounded, 5 lateral glabellar lobes. Axial furrows moderate depth, shallow adjacent to lobe L1, slightly concave; preglabellar furrow very shallow, moderately curved; lateral glabellar furrows shallow or very shallow, F1 and F2 furrows shallow, directed slightly posteriorly, F3 and F4 furrows very shallow, directed slightly anteriorly. Occipital ring sagittal length 20–25% glabellar length, not elevated above glabella, low convexity; very short, narrow occipital spine or node; furrow slightly curved anteriorly, deep pits laterally, shallow depth medially; posterior margin curved. Frontal area length 10–25% cranidial length. Preglabellar field flat and level, below plane of glabella; 60–75% of frontal area. Anterior border slightly convex, slightly to strongly upsloping, uniform thickness, evenly curved, 25–40% of frontal area. Anterior border furrow evenly curved, moderately shallow to very shallow, shallower than axial furrows. Plectrum moderately well defined; posterior margins strongly curved, beginning approximately 15% anterior border width from anterolateral corners. Fixigena width, exclusive of palpebral lobe, 45–60% gla-

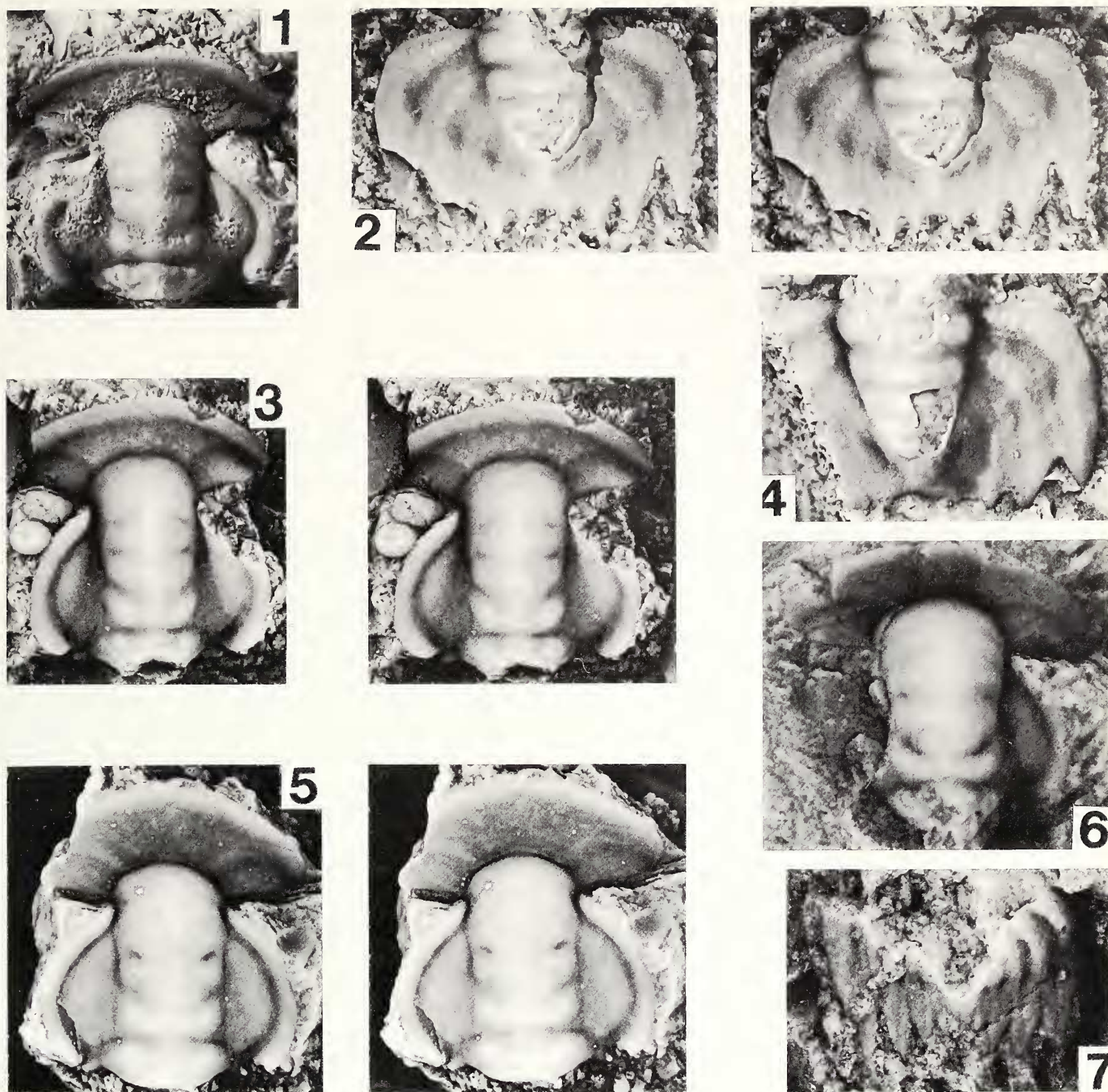


Figure 29. *Zacanthoides divergens* Rasetti. 1–4, *Zacanthoides divergens limbus*, new subspecies. 1, Paratype cranidium (LACMIP 11772), LACMIP locality 15495, exfoliated, $\times 5.1$. 2, Stereo pair of paratype pygidium (LACMIP 11769), LACMIP locality 15538, partially exfoliated, $\times 7.7$. 3, Stereo pair of holotype cranidium (LACMIP 11767), LACMIP locality 15543, exfoliated, $\times 9.5$. 4, Paratype pygidium (LACMIP 11770), LACMIP locality 15538, not exfoliated, $\times 10.1$. 5, *Zacanthoides divergens*, new subspecies A, stereo pair of cranidium (LACMIP 11763), LACMIP locality 15540, not exfoliated, $\times 7.8$. 6, 7, *Zacanthoides divergens divergens* Rasetti. 6, Small cranidium (LACMIP hypotype 11761), LACMIP locality 15601, mostly exfoliated, $\times 12.3$. 7, Partial pygidium (LACMIP hypotype 11762), LACMIP locality 15601, exfoliated, $\times 11.1$.

bellar width, very low convexity, very slightly up-sloping. Palpebral lobe narrow, width 10–20% lobe length; long, length 65–75% glabellar length; intersecting with glabella at F4 furrow; anterior margin located adjacent to 15–25% glabellar length from anterior margin of frontal lobe; furrow moderate depth, narrow. Ocular ridge absent. Posterior area of fixigena unknown.

Librigena small; moderately wide; lateral margin moderately curved. Genal field slightly concave, moderately wide. Border width narrow; moderately convex, elevated above genal field, level; lateral

border furrow moderately shallow, narrow, uniform depth; posterior border furrow shallow, narrow, uniform depth. Genal spine moderately long, base narrow.

Hypostoma unknown.

Nine thoracic segments, axial rings transversely moderately wide. Pleura sagittally and transversely moderately wide, deep pleural furrow, convex pleural lobes; terminates in posterior directed spines.

Pygidium small, length 2.4–2.9 mm; subrectangular, length 55–60% width; anterior margin straight; lateral margins slightly curved; posterior margin

slightly curved, 4 flat, short spines of unequal size, anteriorly positioned spine most developed; low convexity (sag. and trans.), height approximately 25% width. Axis moderately tapered, axial mid-width 70–80% axial anterior width, axial anterior width 35–40% pygidial width; axial length 80–85% pygidial length, small, weak postaxial ridge; 3 axial rings, high convexity, no spines or nodes; terminal axial piece sharply rounded; axial furrows moderately shallow to very shallow posteriorly; axial ring furrow L1 moderate depth, L2 and L3 shallow to very shallow on exterior surface, shallowing medially. Pleural regions well defined, transversely elongate, rectangularly shaped; very low convexity, slightly downsloping; 2 pleural furrows wide, moderately shallow to shallow, extending to posterior margin, laterally directed then curved strongly posterior; interpleural furrows not present. Pleural lobes have granules near axis. Border very poorly defined, moderate width, narrowing medially, width 5–20% pygidial length; flat, lower elevation than remaining pleural field, level; border furrow absent.

Exoskeleton thin; small, densely spaced granules on pleural lobes of pygidia near axis; other parts smooth on external and internal surfaces.

REMARKS. The emended diagnosis and descriptions are based on the figured specimens of Rasetti (1951) and the specimens collected for this study. *Zacanthoides divergens* is most similar to *Z. sampsoni* Resser, 1939c, but differs in having strongly divergent facial sutures anterior to palpebral lobes, a moderately well-defined plectrum, four pairs of pygidial spines, and granular ornamentation.

Zacanthoides divergens is subdivided into three subspecies based on differences in the strength of the anterior border and/or the sagittal length of the frontal area.

MATERIAL. See subspecies.

OCCURRENCE. See subspecies.

Zacanthoides divergens divergens

Rasetti, 1951

Figures 29.6, 29.7

Zacanthoides divergens Rasetti, 1951:146–147, pl. 32, figs. 8–10.

DIAGNOSIS. *Zacanthoides divergens* with cranidium with anterior border poorly defined and upturned, frontal area approximately 10% cranial length.

REMARKS. *Zacanthoides divergens divergens* differs from *Z. divergens limbus* in having a more poorly defined anterior border that is upturned, very shallow anterior border furrow, and frontal area length 10% of the cranial length. *Zacanthoides divergens divergens* differs from *Z. divergens*, new subspecies A, in having a frontal area length 10% of the cranial length.

Two small, fragmented cranidia and one small, fragmented pygidium of *Zacanthoides divergens divergens* were collected from the Eldorado For-

mation, northern Egan Range. These specimens agree in all aspects with the specimens of Rasetti (1951) from British Columbia, Canada.

HYPOTYPES. LACMIP 11761, 11762 from LACMIP locality 15601.

OTHER MATERIAL. LACMIP locality 15601, 1 cranidium.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Stephen Formation, British Columbia (Rasetti, 1951). Eldorado Formation, northern Egan Range, Nevada.

Zacanthoides divergens limbus,
new subspecies

Figures 29.1–29.4

Zacanthoides, n. sp. Sundberg, 1991:388 fig. 2.9.

DIAGNOSIS. *Zacanthoides divergens* with cranidium with anterior border moderately well defined and not upturned, shallow anterior border furrow, frontal area 18–23% cranial length.

REMARKS. *Zacanthoides divergens limbus* differs from *Z. divergens divergens* as stated above. *Zacanthoides divergens limbus* differs from *Z. divergens*, new subspecies A, in having a slightly shorter frontal area (18–23% of the cranial length) and a well-defined anterior border.

ETYMOLOGY. Latin, *limbus* = border, named for the moderately well-defined anterior border.

HOLOTYPE. Cranidium (LACMIP 11767) from the Trailer Limestone, Dugway Mountains, Utah (LACMIP locality 15543).

PARATYPES. LACMIP 11764, 11765 from LACMIP locality 15499; LACMIP 11766 from LACMIP locality 15517; LACMIP 11768 from LACMIP locality 15543; LACMIP 11958 from LACMIP locality 15540; LACMIP 11769–11771 from LACMIP locality 15538; LACMIP 11772, 11773 from LACMIP locality 15495.

OTHER MATERIAL. LACMIP locality 15495, 6 cranidia, 1 pygidium; LACMIP locality 15498, 1? cranidium; LACMIP locality 15517, 1 cranidium; LACMIP locality 15538, 4 cranidia, 1 pygidium; LACMIP locality 15540, 2 cranidia; LACMIP locality 15543, 1 cranidium; LACMIP locality 15564, 1 cranidium; LACMIP locality 15580, 1 cranidium, 1 pygidium.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains and House Range, Utah. Trailer Limestone, Dugway Mountains, Utah. Pole Canyon Limestone, Member E, Snake Range and Patterson Pass, Nevada.

Zacanthoides divergens,
new subspecies A

Figure 29.5

DIAGNOSIS. *Zacanthoides divergens* with cranidium with anterior border moderately poorly defined, anterior border furrow absent, frontal area 23–24% cranial length.

REMARKS. *Zacanthoides divergensis*, new subspecies A, differs from *Z. divergensis divergensis* and *Z. divergensis limbus* as stated above. The nomenclature for *Z. divergensis*, new subspecies A, is left open because of the absence of additional well-preserved cranidia and associated pygidia.

HYPOTYPE. LACMIP 11763 from LACMIP locality 15540.

OTHER MATERIAL. LACMIP locality 15540, 1 cranidium.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Trailer Limestone, Dugway Mountains, Utah.

***Zacanthoides fronslicinus*,
new species**

Figure 30

DIAGNOSIS. *Zacanthoides* with cranidium with strongly upturned preglabellar field, anterior border not defined; nearly effaced lateral glabellar furrows; short ocular ridges. Pygidium subrectangular, 4 pairs of short, thin, rounded, unequal length spines pointing toward midline of pygidium.

DESCRIPTION. Cranidium small to moderate size, length 4.9–9.8 mm; hourglass shape, length 80–85% width; moderately low sagittal and low transverse convexity, height 25–30% width; anterior margin moderately curved, anterior margin width 65–80% cranidial width; posterior margin, excluding occipital ring, projecting anteriorly. Facial sutures moderately divergent from ends of palpebral lobes to anterior border; moderately divergent across anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 85–90% and width 35–45% cranidial length; glabella width 30–35% cranidial width; sides slightly divergent with expanding frontal lobe, width at anterior end 115–125% glabellar width; moderate to low sagittal and low transverse convexity; frontal lobe bluntly rounded; 4 lateral glabellar lobes. Axial furrows moderately shallow depth, shallow adjacent to lobe L1, slightly concave; preglabellar furrow shallow, moderately curved; lateral glabellar furrows nearly effaced. Occipital ring sagittal length 20–25% glabellar length, not elevated above glabella, low convexity; short spine; furrow slightly curved posteriorly, very shallow depth; posterior margin curved. Frontal area length 10–15% cranidial length, not differentiated; strongly upturned medially, less so laterally. Anterior border furrow absent. Plectrum poorly defined; posterior margins slightly curved, beginning at anterolateral corners. Fixigena width, exclusive of palpebral lobe, 45–55% glabellar width, low convexity, level. Palpebral lobe narrow, width 10–20% lobe length; long, length 45–55% glabellar length; anterior margin located adjacent to 25–30% glabellar length from anterior margin of frontal lobe; furrow moderate depth, narrow. Ocular ridge short to absent, directed very strongly posterolaterally from glabella at 40–50° to

axial trend. Posterior area of fixigena narrow, exsagittal width 10–15% glabellar length, length 35–45% glabellar length, curved anteriorly; posterior border bifurcates laterally, posterior most, secondary border very low convexity, narrow, anterior most, primary border low convexity, uniform thickness; border furrow bifurcated, posterior most very shallow, anterior most shallow, shallowing laterally and joining laterally.

Librigena small, length 7.8–7.9 mm, wide, width 90% length without spine; height 20–30% width; lateral margin gently curved. Ocular platform narrow, width 2–3% librigenal width, strongly concave. Genal field flat to slightly concave near border, width approximately 40% librigenal width. Border width 10–15% librigenal width; gently convex, elevated above genal field, level, upturned anteriorly; lateral border furrow shallow, broad, uniform depth; posterior border furrow shallow, broad, uniform depth. Genal spine long, 105–110% librigenal length, base narrow.

Hypostoma and thorax unknown.

Pygidium small, length 1.5–2.5 mm; subrectangular, length 45–50% width; anterior margin strongly curved posteriorly; lateral margins curved; posterior margin moderately curved, 6 round, thin, slightly upturned, short spines of unequal size, anteriorly positioned spine most developed, spines directed toward median line of pygidia; low convexity (sag. and trans.), height 25–30% width. Axis moderately tapered, axial mid-width 80–85% axial anterior width, axial anterior width 40–50% pygidial width; axial length 70–85% pygidial length, small, strong postaxial ridge; 2 axial rings, high convexity, no spines or nodes; terminal axial piece broadly rounded; axial furrows very shallow; axial ring furrow L1 shallow and L2 very shallow, shallowing laterally. Pleural regions well defined, sagittally elongate, triangular shaped; very low convexity, slightly down-sloping; 2 pleural furrows wide, very shallow, extending to posterior margin, posteriorly directed; interpleural furrows not present. Border very poorly defined, narrow to moderate width, width 10–20% pygidial length; flat, level; border furrow absent.

Exoskeleton thin; smooth on all external and internal surfaces.

REMARKS. *Zacanthoides fronslicinus* is unlike most other species of *Zacanthoides* in its strongly upturned frontal area, nearly effaced lateral glabellar furrows, short ocular ridges, and its four thin, in-turned, pygidial spines. *Zacanthoides divergensis divergensis* possesses a strongly upturned frontal area, but *Z. fronslicinus* differs in its nearly effaced lateral glabellar furrows, short ocular ridges, and its four thin pygidial spines. The short ocular ridges result from the presence of fixigenae adjacent to the frontal lobe, although this portion of the fixigena is absent in some specimen. Most species of *Zacanthoides* lack this portion of fixigena and the palpebral lobes abut against the glabella. Four specimens of *Zacanthoides* from the Trailer Limestone,

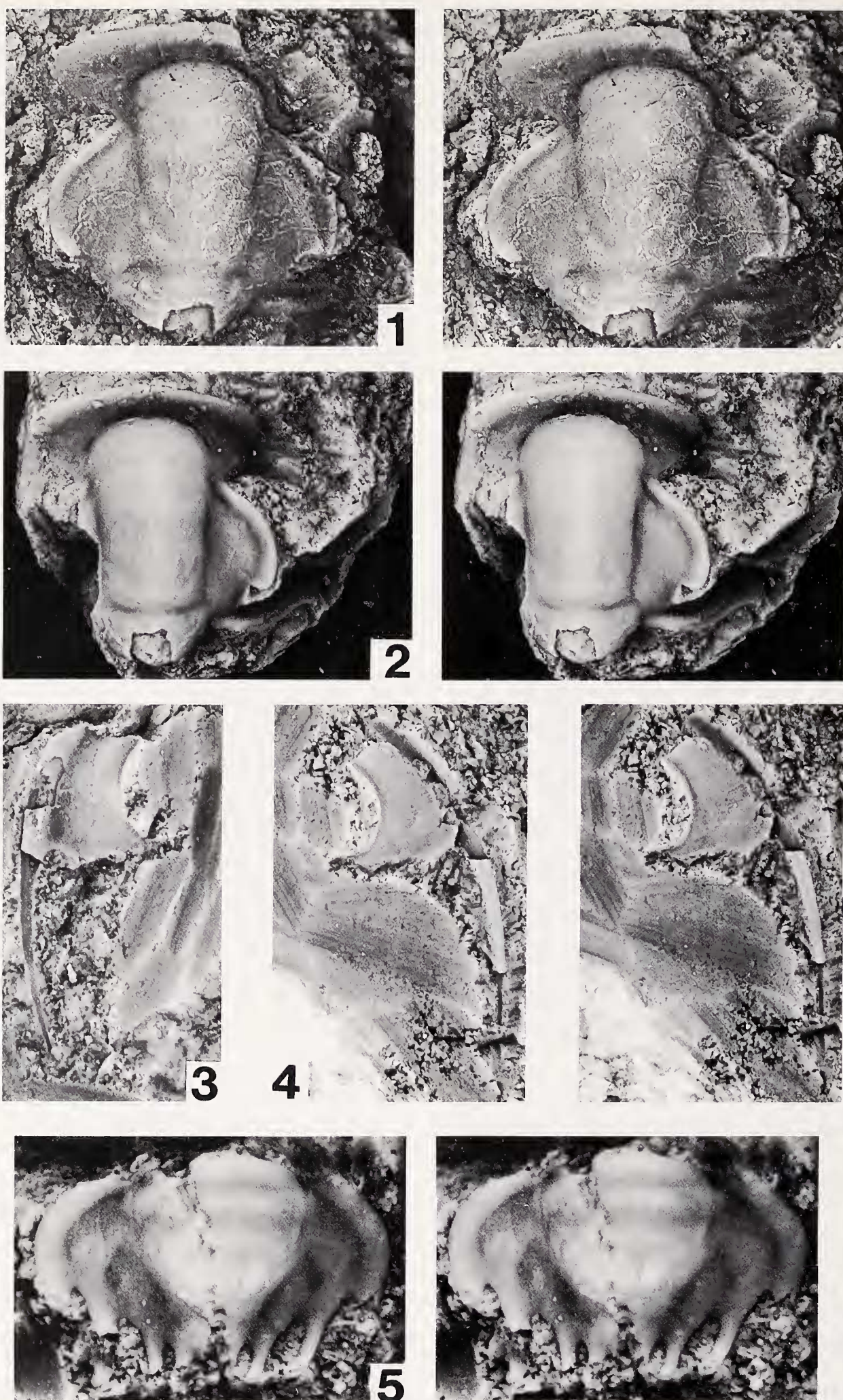


Figure 30. *Zacanthoides fronslicinus*, new species. 1, Stereo pair of paratype cranidium (LACMIP 11781), LACMIP locality 15492, not exfoliated, $\times 4.7$. 2, Stereo pair of holotype cranidium (LACMIP 11782), LACMIP locality 15494, not exfoliated, $\times 5.8$. 3, Partial paratype free cheek (LACMIP 11780), LACMIP locality 15491, not exfoliated, genal spine missing, $\times 6.8$. 4, Stereo pair of partial paratype free cheek (LACMIP 11779), LACMIP locality 15491, exfoliated, $\times 2.5$. 5, Stereo pair of small paratype pygidium (LACMIP 11775), LACMIP locality 15528, not exfoliated, $\times 14.9$.

Dugway Range (LACMIP localities 15534 and 15536), are similar in overall morphology to *Z. fronslicinus*, but they have level anterior borders. These specimens are questionably assigned to the species.

ETYMOLOGY. Latin, *frons* = front and *licinus* = bent or turned upward, for the upturned frontal area.

HOLOTYPE. Cranidium (LACMIP 11782) from the Swasey Limestone, Drum Mountains, Utah (LACMIP locality 15494).

PARATYPES. LACMIP 11774, 11775 from LACMIP locality 15528; LACMIP 11776, 11777 from LACMIP locality 15529; LACMIP 11778 from LACMIP locality 15490; LACMIP 11779, 11780 from LACMIP locality 15491; LACMIP 11781 from LACMIP locality 15492.

OTHER MATERIAL. LACMIP locality 15490, 5 cranidia, 1 librigena, 1 pygidium; LACMIP locality 15491, 2 cranidia, 1 librigena; LACMIP locality 15492, 4 cranidia; LACMIP locality 15494, 5 cranidia, 2 pygidia, 1 librigena; LACMIP locality 15528, 10 cranidia; LACMIP locality 15529, 5 cranidia; LACMIP locality 15530, 1 cranidium, 1 pygidium; LACMIP locality 15531, 1 cranidium; LACMIP locality 15532, 1 cranidium, 1 pygidium; LACMIP locality 15533, 3 cranidia; LACMIP locality 15534, 1? cranidium; LACMIP locality 15536, 3? cranidia.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains, Utah. Trailer Limestone, Dugway Mountains, Utah.

Zacanthoides walapai

Resser, 1945

Figure 31

Zacanthoides walapai Resser, 1945:194, pl. 20, figs. 19–20.

EMENDED DIAGNOSIS. *Zacanthoides* with cranidium with moderately divergent anterior facial sutures, frontal area 5–10% cranidial length, very shallow anterior border furrow. Pygidium subovoid with 1 pair of moderate length, lateral spines; 1–3 pairs of short to very short, flat, posterior spines.

EMENDED DESCRIPTION. Cranidium large, length 16.3–17.8 mm; subrectangular; moderate sagittal and low transverse convexity; anterior margin moderately curved; posterior margin not preserved. Facial sutures moderately divergent from ends of palpebral lobes to anterior border; nearly parallel across anterior border; probably strongly divergent posterior of palpebral lobes. Glabella elongate, length 90–95% and width 50–55% cranidial length; sides parallel to slightly convergent, frontal lobe not expanding, width at anterior end 85–90% glabellar width; high to low sagittal and low transverse convexity; frontal lobe bluntly rounded, 4 lateral glabellar lobes. Axial furrows moderate to shallow depth, shallowest adjacent to lobe L4, slightly concave; preglabellar furrow very shallow, moderately curved; lateral glabellar furrows moderate depth to very shallow, F1 bifurcated, moderately deep, directed posteriorly, F2 furrow shal-

low, directed slightly posteriorly, F3 and F4 furrows very shallow, directed anteriorly. Occipital ring sagittal length 15–20% glabellar length, not elevated above glabella, low convexity; no occipital spine or node; furrow slightly curved anteriorly, deep pits laterally, shallow depth medially; posterior margin curved. Frontal area length 5–10% cranidial length. Preglabellar field flat and level, below plane of glabella; 50–55% of frontal area. Anterior border slightly convex, slightly upsloping, thickening laterally, evenly curved; 45–50% frontal area length. Anterior border furrow evenly curved, very shallow, shallower than axial furrows. Plectrum poorly defined; posterior margins slightly curved, beginning at anterolateral corners. Fixigena width, exclusive of palpebral lobe, 30–35% glabellar width, low convexity, very slightly downsloping. Palpebral lobe narrow; long, length 55–60% glabellar length; anterior margin located adjacent to 25–30% glabellar length from anterior margin of frontal lobe; furrow moderate depth, narrow. Ocular ridge short, weak, directed very strongly posterolateral 40–50° to axial trend of glabella. Posterior area of fixigena unknown, width approximately 10% glabella length.

Librigena moderate size, width of incomplete specimen 5.5 mm; moderately wide, lateral margin gently curved. Genal field very slightly convex. Border narrow; moderately convex, flat on top, level; lateral border furrow, broad, uniform depth; posterior border furrow shallow, broad, uniform depth. Genal spine moderate length, base narrow.

Hypostoma and thorax unknown.

Pygidium moderate size, length 7.1 mm; suboval, length approximately 80% width; anterior portion of anterior margin slightly curved posteriorly, laterally portion straight; lateral margins slightly curved; posterior margin moderately curved, 4 pairs of flat, moderate length to short spines of unequal size, anteriorly positioned spine most developed, remaining spines very short to incipient; low convexity (sag. and trans.), height approximately 35% width. Axis moderately tapered, axial mid-width approximately 75% axial anterior width, axial anterior width approximately 50% pygidial width; axial length approximately 75% pygidial length, large, broad, weak postaxial ridge; 4 axial rings, high convexity, small nodes; terminal axial piece sharply rounded; axial furrows moderately shallow to very shallow posteriorly; axial ring furrows shallow, shallowing medially. Pleural regions well defined, sagittally elongate, subtriangular shaped; very low convexity, slightly downsloping; pleural furrows wide, moderately shallow to shallow, extending to posterior margin, posteriorly directed; interpleural furrows not present. Border very poorly defined, moderate width, narrowing medially, width approximately 25% pygidial length; flat, slightly upturned; border furrow very broad and shallow.

Exoskeleton thin; smooth on all external and internal surfaces.

REMARKS. The emended diagnosis and descriptions are based on the figured specimens of Resser (1945) and the specimens collected for this study.

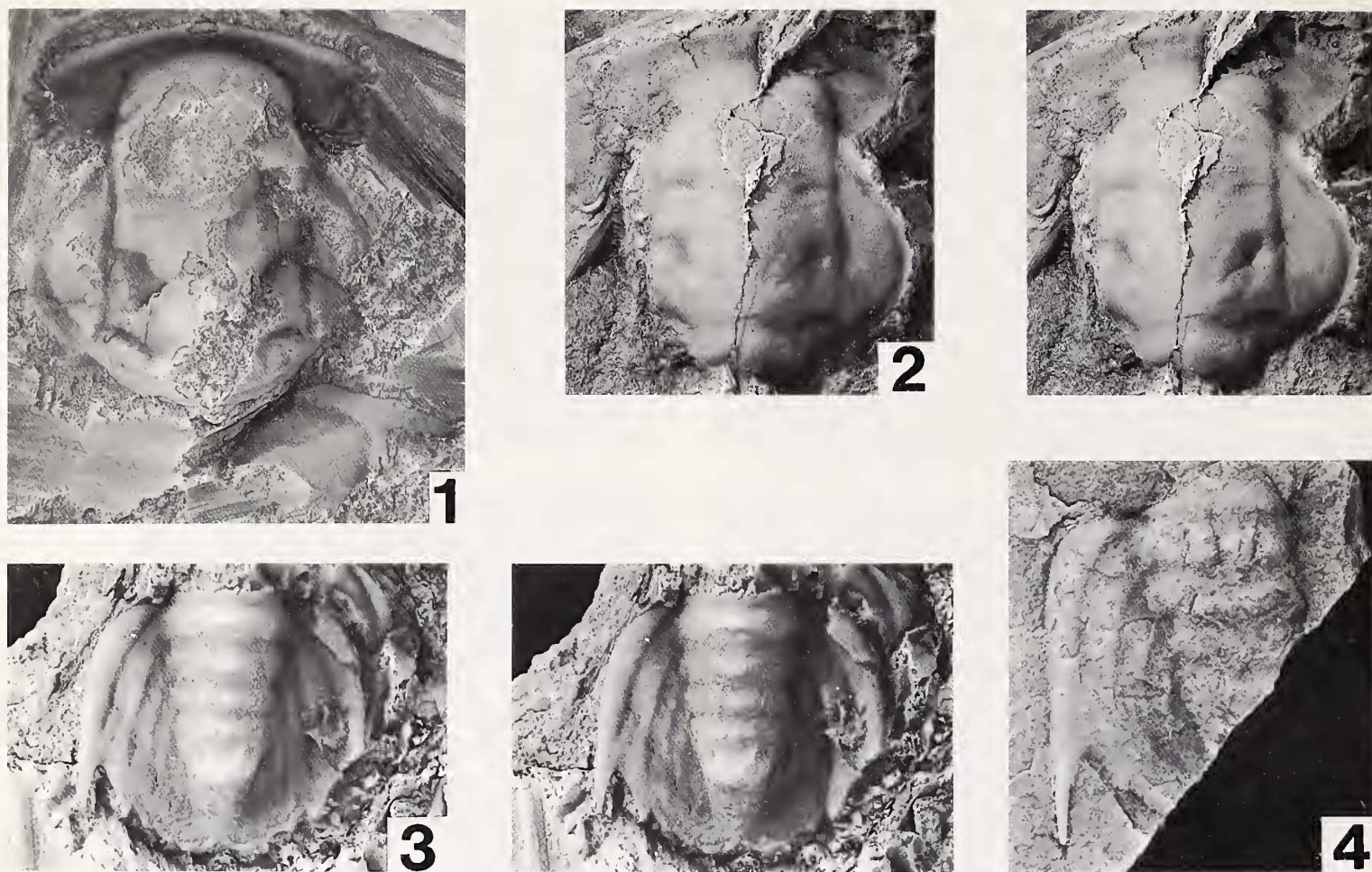


Figure 31. *Zacanthoides walapai* Resser. 1, Crushed partial cranidium (LACMIP hypotype 11785) and free cheek, LACMIP locality 15588, exfoliated, $\times 2.1$. 2, Stereo pair of latex mold of partial cranidium (LACMIP hypotype 11784), LACMIP locality 15588, exfoliated, $\times 2.1$. 3, Stereo pair of distorted pygidium (LACMIP hypotype 11786), LACMIP locality 15550, exfoliated, $\times 3.4$. 4, Partial pygidium (LACMIP hypotype 11783) in shale, LACMIP locality 15402, exfoliated, $\times 3.0$.

Zacanthoides walapai from the upper Chisholm Formation and stratigraphically equivalent units differs from the specimens from the Bright Angel Shale by having three pairs of small to very small spines on the pygidium in addition to the larger lateral spines, and in the absence of a small occipital node. These small spines and the absent occipital node are not considered here as significant characters for the erection of a new species. The librigena is known only from a partial specimen; thus, ratios are not given in the description. Ratios given in the pygidium description are based on distorted specimens; thus, they are only approximate ratios.

Zacanthoides walapai is distinct from most *Zacanthoides* species in its suboval pygidium with only

moderate size lateral spines and very small inner spine pairs. *Zacanthoides walapai* is most similar to *Z. adjunctus* Resser, 1939a, but differs in the shorter length of the four pairs of pygidial spines. *Zacanthoides walapai* is also similar to *Z. submuticus* Rasetti, 1951, but differs in having a longer, suboval-shaped pygidium with large lateral spines and a less developed anterior border on the cranidium.

HYPOTYPES. LACMIP 11783 from LACMIP locality 15502; LACMIP 11784, 11785 from LACMIP locality 15588; LACMIP 11786 from LACMIP locality 15550.

OTHER MATERIAL. LACMIP locality 15502, 2 cranidia, 3 pygidia; LACMIP locality 15549, 1 cranidium, 3 pygidia; LACMIP locality 15550, 5 cranidia, 1 librigena, 3 pygidia; LACMIP locality 15551, 8 cranidia, 2 pygidia; LACMIP locality 15582, 1 pygidium; LACMIP locality 15584, 1 cranidium; LACMIP locality 15588, 2 cranidia, 1 librigena; LACMIP locality 15589, 1 cranidium, 1 librigena, 1 pygidium; LACMIP locality 15607, 1 cranidium, 1 pygidium.

OCCURRENCE. *Proehmaniella* Subzone, *Ehmaniella* Biozone. Bright Angel Shale, Grand Canyon, Utah (Resser, 1945). Chisholm Formation, House Range, Utah. Eldorado Formation, northern Egan Range, Nevada. Pole Canyon Limestone, Member C, Snake Range, Nevada.

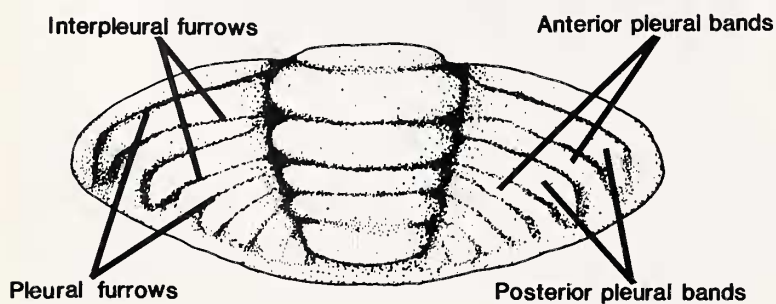


Figure 32. Development of the anterior and posterior pleural bands on an Ehmaniellidae.

Order Ptychopariida
Swinnerton, 1915

Suborder Ptychopariina
Richter, 1933

Family Ehmaniellidae,
new family

TYPE GENUS. *Ehmaniella* Resser, 1937.

REMARKS. Ehmaniellidae are typified by the possession of (1) thin exoskeletons; (2) relatively elongate glabellae with bluntly rounded to rounded frontal lobes; (3) typically only the F1 lateral glabellar furrows bifurcate; (4) converging, relatively straight axial furrows; and (5) micropygous pygidia with poorly defined borders, no or very shallow border furrows, moderately convex anterior and posterior pleural bands in exsagittal profile, and pleural and interpleural furrows that join at the border (Fig. 32). Taxa assigned to Ehmaniellidae include: *Altiocculus*; *Ehmania* Resser, 1935; *Ehmaniella*; *Elrathia*; *Elrathiella*; *Parehmania* Deiss, 1939; *Proehmaniella*; *Pseudalokistocare*, new genus; *Pseudomexicella*, new genus; *Schopfaspis* Palmer and Gatehouse, 1972; *Trachycheilus*; and *Tympanuella*. Ehmaniellidae is further subdivided into the new subfamilies Ehmaniellinae and Altiocculinae.

Some taxa assigned to this family have secondarily lost some of the diagnostic morphological characters, but these taxa are similar enough to other taxa within Ehmaniellidae to also be included in the family. For example, the pygidia of *Elrathiella dugwayensa*; *E. rectangularia*, new species; and *Pseudomexicella hestia*, new species have lost the convex development of the anterior pleural bands (although some pygidia of *E. rectangularia* have weakly convex anterior pleural bands). However, these species have the cranidial and the other pygidial characters that fit well in Ehmaniellidae. *Trachycheilus* also deviates from the typical familial characters in its inflated glabella, which gives the glabella slightly convex axial furrows. The pygidial characters of *Trachycheilus* and the morphologic similarity between cranidia of *Trachycheilus*? sp. A and *Proehmaniella basilica* indicate that inclusion of the genus in the family is appropriate.

The trilobites assigned to Ehmaniellidae have been typically placed in Alokistocaridae Resser, 1939a (Howell in Harrington et al., 1959). However, constructing a differential diagnosis for Alokistocaridae is not possible due to the overall simple cranidial morphology of the group and because of the poorly known morphology of several taxa in the family, including the type species of the type genus of the family (*Alokistocare subcoronatum* [Hall and Whitfield, 1877]; see below). This study shows that *Ehmaniella* and the other genera listed above are closely related and form a distinct group based on

(1) their morphological similarity of cranidial and pygidial characters, (2) their close stratigraphic context, and (3) their morphological dissimilarity to several other taxa of Alokistocaridae. The most diagnostic features of Ehmaniellidae are their elongated, conical glabella with a bifurcated F1 glabellar furrow and pygidia that are non-triangular, the pleural and intrapleural furrows joining near the margin, and the moderate convex development of the anterior and posterior pleural bands.

The overall morphology of many of the remaining taxa in Alokistocaridae is poorly known. For example, *Alokistocare subcoronatum*, a key type species, is known from only a few cranidia with no pygidia, librigenae, or thoracic segments that can be assigned directly to the species. The pygidia of complete specimens of *Alokistocare* from the *Glossopleura* Biozone are unlike the ehmaniellid pygidia. These older pygidia have a triangular outline, posterior pleural bands that are not developed, and the pleural and interpleural furrows that do not join near the margin. In addition, the pygidia *Chancia*, *Elrathina*, and *Nyella*, which first appear in the *Glossopleura* or earlier biozones, are also similar to the pygidia of *Alokistocare* from the *Glossopleura* Biozone.

Subfamily Ehmaniellinae,
new subfamily

TYPE GENUS. *Ehmaniella* Resser, 1937.

REMARKS. Ehmaniellinae is characterized by cranidia with (1) well-defined, relatively elongate (65–90% cranidial length), tapered glabellae with moderate to deep axial furrows, shallow to moderate depth lateral glabellar furrows, and bluntly to strongly rounded frontal lobes; (2) relatively large palpebral lobes; (3) moderately strong ocular ridges; (4) tapered anterior borders with moderate depth anterior border furrow; (5) relatively level preglabellar field and anterior area of fixigena; and (6) no medial swelling within the frontal area. This subfamily differs from the Altiocculinae in its relatively longer glabella, slightly downsloping preglabellar field and anterior area of fixigena, and no medial swelling in the frontal area. Taxa assigned to Ehmaniellinae include: *Ehmania*, *Ehmaniella*, *Elrathia*, *Elrathiella*, *Proehmaniella*, *Pseudomexicella*, *Trachycheilus*, and *Tympanuella*.

Genus *Ehmaniella* Resser, 1937

TYPE SPECIES. *Crepicephalus* (*Loganellus*) *quadrans* Hall and Whitfield, 1877.

EMENDED DIAGNOSIS. Ehmaniellinae with subrectangular cranidium with divergent facial sutures anterior of palpebral lobes; moderate to long palpebral lobes (35–50% glabellar length); well-defined anterior border, narrow to moderate width (10–20% cranidial length), moderately to slightly tapered; preglabellar field sagittally narrow to mod-

erately wide (30–60% frontal area length); moderately tapered glabella; bluntly rounded frontal lobe; exsagittally narrow posterior area of fixigenae (20–35% glabellar length). Pygidium suboval to subrectangular to alate with blunt axis; 3–4 axial rings; moderate depth pleural furrows; moderately convex posterior pleural bands; moderately convex to weak anterior pleural bands.

REMARKS. The diagnosis is modified from Palmer (1954) to increase the range of some characters (i.e., border/preglabellar field ratios, tapering of anterior border). A relatively moderate to strongly tapered glabella with a blunted frontal lobe is the most diagnostic feature of the genus. *Ehmaniella* differs from *Proehmaniella* in its less rounded frontal lobe, longer palpebral lobes, more posterolaterally projected eye ridges, narrower sagittal width of the anterior border, and narrower exsagittal width of the posterior area of fixigenae.

Ehmaniella angustigena,
new species

Figure 33

DIAGNOSIS. *Ehmaniella* with cranium with bluntly rounded frontal lobe; fine granular ornamentation; flat to slightly concave, moderately strongly curved, slightly downsloping, slightly tapered, wide anterior border, 55–70% of frontal area length; narrow fixigenae (30–40% glabellar width). Pygidium alate, elongate axis, moderately convex anterior pleural bands.

DESCRIPTION. Cranium small to moderate size, length 4.1–10.1 mm; subsquare, length 65–70% width; low convexity (sag. and trans.), height 30–35% width; anterior margin moderately strongly curved, anterior margin width 70–80% cranial width; posterior margin, excluding occipital ring, slightly backswept. Facial sutures moderately divergent from ends of palpebral lobes to approximately middle of anterior border; moderately convergent across anterior half of anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 70–75% and width 55–65% cranial length; glabella width 35–40% cranial width; moderately tapered, with at anterior end 75–85% glabellar width; moderately low convexity (sag. and trans.); anterior end very bluntly rounded, 3 lateral glabellar lobes. Axial furrows moderately deep, deeper posteriorly, straight to very slightly concave; preglabellar furrow shallow, uniform depth; lateral glabellar furrows very shallow, F1 furrow bifurcated, directed posteriorly, F2 furrow directed laterally, F3 furrow directed slightly anteriorly. Occipital ring sagittal length 15–25% glabellar length, not elevated above glabella, low convexity; small occipital node?; furrow straight, deep laterally, very shallow medially; posterior margin curved. Frontal area length 25–30% cranial length, subequally divided. Preglabellar field very slightly convex, moderately downsloping, length 30–45%

frontal area length. Anterior border flat to very slightly concave, downsloping, slightly tapering laterally, evenly curved, sagittal length 55–70% frontal area length. Anterior border furrow evenly curved, shallow laterally, very shallow medially, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 30–40% glabellar width, low convexity, upsloping. Palpebral lobe crescent shaped, narrow to moderately wide, width 25–30% lobe length, upsloping; long, length approximately 45% glabellar length; anterior margin located adjacent to 30–35% glabellar length from anterior margin of frontal lobe; furrow very shallow. Ocular ridge moderate strength, directed strongly posterolaterally from glabella at 60–65° to axial trend. Posterior area of fixigena exsagittal width 20–25% glabellar length; length 55–60% glabella length; sharply terminated. Posterior border strongly convex, slightly wider distally; border furrow narrow, deep, slightly curved posteriorly, slightly wider laterally.

Librigena small, length 1.5–1.8 mm; moderately wide, width approximately 50% length without spine; lateral margin moderately curved. Genal field moderately convex, width 40–45% librigenal width. Border width approximately 30% librigenal width, uniform thickness; moderately convex; lateral border furrow moderate depth; posterior border furrow moderate depth. Genal spine moderate length, approximately 50% librigenal length.

Hypostoma and thorax unknown.

Pygidium small, length 1.5–1.8 mm; alate, length approximately 45% width; margin smooth, anterior margin slightly curved posteriorly; lateral margins evenly curved; posterior margin slightly flattened; moderate convexity (sag. and trans.), height 40–45% width. Axis slightly tapered, axial mid-width 85–90% axial anterior width, axial anterior width 40–45% pygidial width; axial length 75–85% pygidial length, no postaxial ridge; 3 axial rings, high convexity; terminal axial piece strongly rounded; axial furrow shallow; axial ring furrows shallow depth, deeper laterally. Pleural regions well defined, sagittally elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, moderately deep, does not extend to margin, curved moderately posterior; 3 additional pleural furrows, moderate depth to shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows near margin; anterior and posterior pleural bands moderately convex and developed. Border narrow, width 10–15% pygidial length, widening laterally; flat, level; border furrow absent.

Exoskeleton thin; genal caeca on preglabellar field and anterior area of fixigena; very fine granules on palpebral area of fixigena, posterior area of fixigenae, and ocular ridge; glabella and border smooth on external surface and internal mold. Other parts are smooth on external and internal surfaces.

REMARKS. *Ehmaniella angustigena* is most similar to *E. fronsplanata* in possessing a flat anterior border and an alate pygidium but differs in

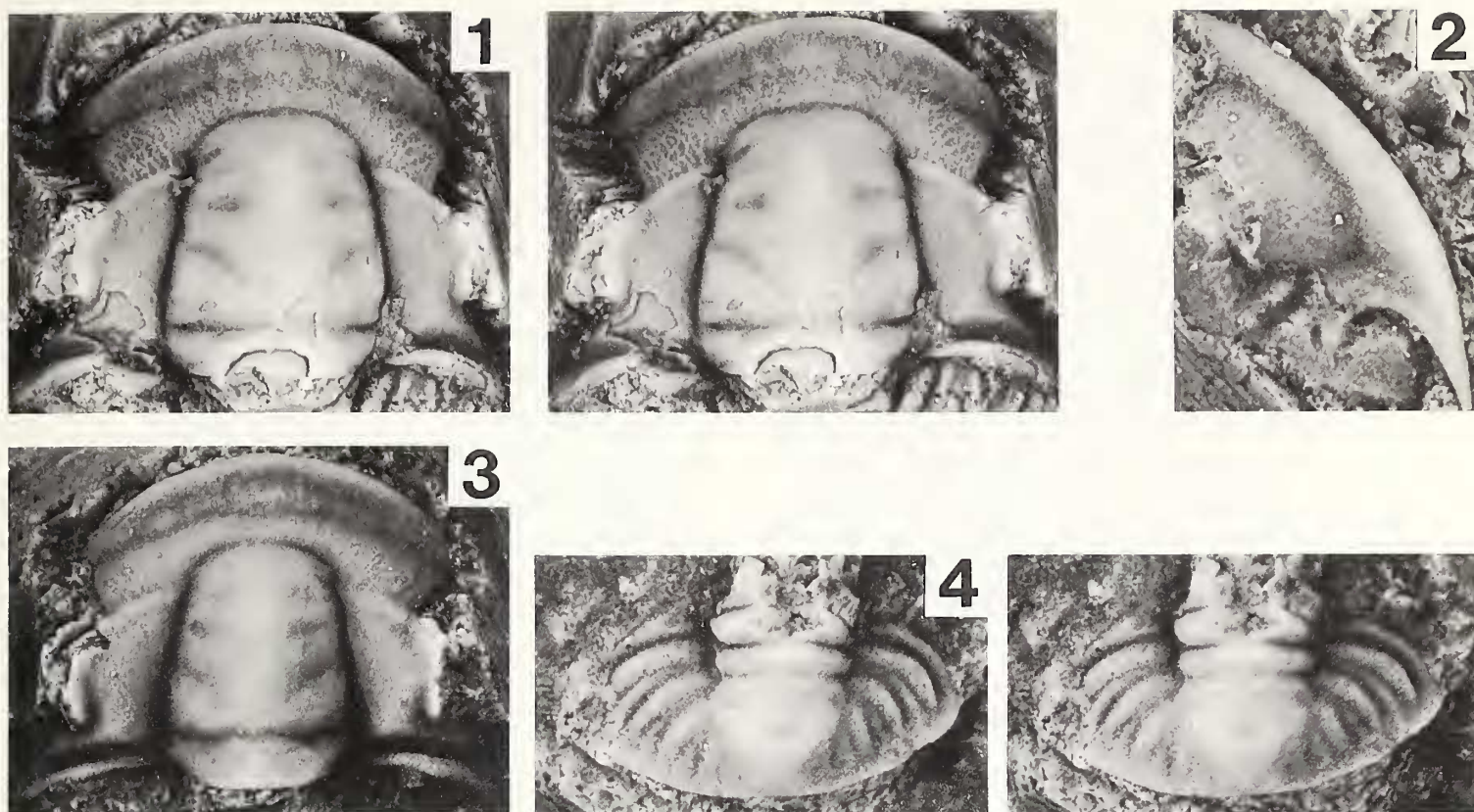


Figure 33. *Ehmaniella angustigena*, new species, LACMIP locality 15595. 1, Stereo pair of holotype cranidium (LACMIP 11788), slightly exfoliated, $\times 4.4$. 2, Paratype free cheek (LACMIP 11793), exfoliated, $\times 11.2$. 3, Paratype cranidium (LACMIP 11789), exfoliated, $\times 6.8$. 4, Stereo pair of paratype pygidium (LACMIP 11790), exfoliated, $\times 11.2$.

having narrower fixigenae, moderately posterolaterally directed ocular ridges, and more uniform width of the anterior border.

ETYMOLOGY. Latin, *angustus* = narrow, *gena* = cheek, for the narrow fixigenae.

HOLOTYPE. Cranidium (LACMIP 11788) from the Eldorado Formation, northern Egan Range, Nevada (LACMIP locality 15595).

PARATYPES. LACMIP 11789–11797 from LACMIP locality 15595; LACMIP 11798 from LACMIP locality 15598.

OTHER MATERIAL. LACMIP locality 15561, 1? cranidium; LACMIP locality 15595, 28 cranidia, 2 pygidia, 1 librigena; LACMIP locality 15596, 5 cranidia, 1 pygidium, 1 librigena; LACMIP locality 15597, 7 cranidia, 3 librigenae; LACMIP locality 15598, 17 cranidia.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Eldorado Formation, northern Egan Range, Nevada. ?Pole Canyon Limestone, Member E, Snake Range, Nevada.

Ehmaniella fronsplanata, new species

Figures 34–36

DIAGNOSIS. *Ehmaniella* with cranidium with very bluntly rounded frontal lobe; smooth to very fine granular ornamentation; slightly convex to concave, moderately curved, downsloping, moderately tapered, wide anterior border (55–65% of frontal area length); wide fixigenae (50–60% glabellar width). Pygidium alate, elongate axis, moderately convex anterior pleural bands.

DESCRIPTION. Cranidium small to moderate

size, length 2.9–5.8 mm; subtrapezoidal, length 70–80% width; low convexity (sag. and trans.), height 15–25% width; anterior margin moderately curved, anterior margin width 70–85% cranidial width; posterior margin, excluding occipital ring, very slightly to slightly backswept. Facial sutures slightly to moderately divergent from ends of palpebral lobes to approximately middle of anterior border; strongly convergent across anterior half of border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 65–70% and width 50–55% cranidial length; glabella width 35–40% cranidial width; strongly tapered, width at anterior end 70–75% glabellar width; moderately low convexity (sag. and trans.); frontal lobe very bluntly rounded, 4 lateral glabellar lobes. Axial furrows moderately deep, deeper posteriorly, straight to very slightly concave; preglabellar furrow shallow, shallowing medially with slightly deeper fossula medially, very slightly curved, poorly developed medial sulcus(?); lateral glabellar furrows very shallow, F1 furrow bifurcated, directed posteriorly, F2 furrow directed laterally, F3 furrow directed slightly anteriorly, F4 furrow very shallow to absent directed slightly anteriorly. Occipital ring sagittal length 20–25% glabellar length, not elevated above glabella, low convexity; very small occipital node; furrow curved slightly anteriorly, deep laterally, very shallow medially; posterior margin curved. Frontal area length 30–35% cranidial length, subequally divided. Preglabellar field slightly convex, moderately downsloping laterally, less downsloping medially, length 35–45% frontal area length. Anterior border flat to

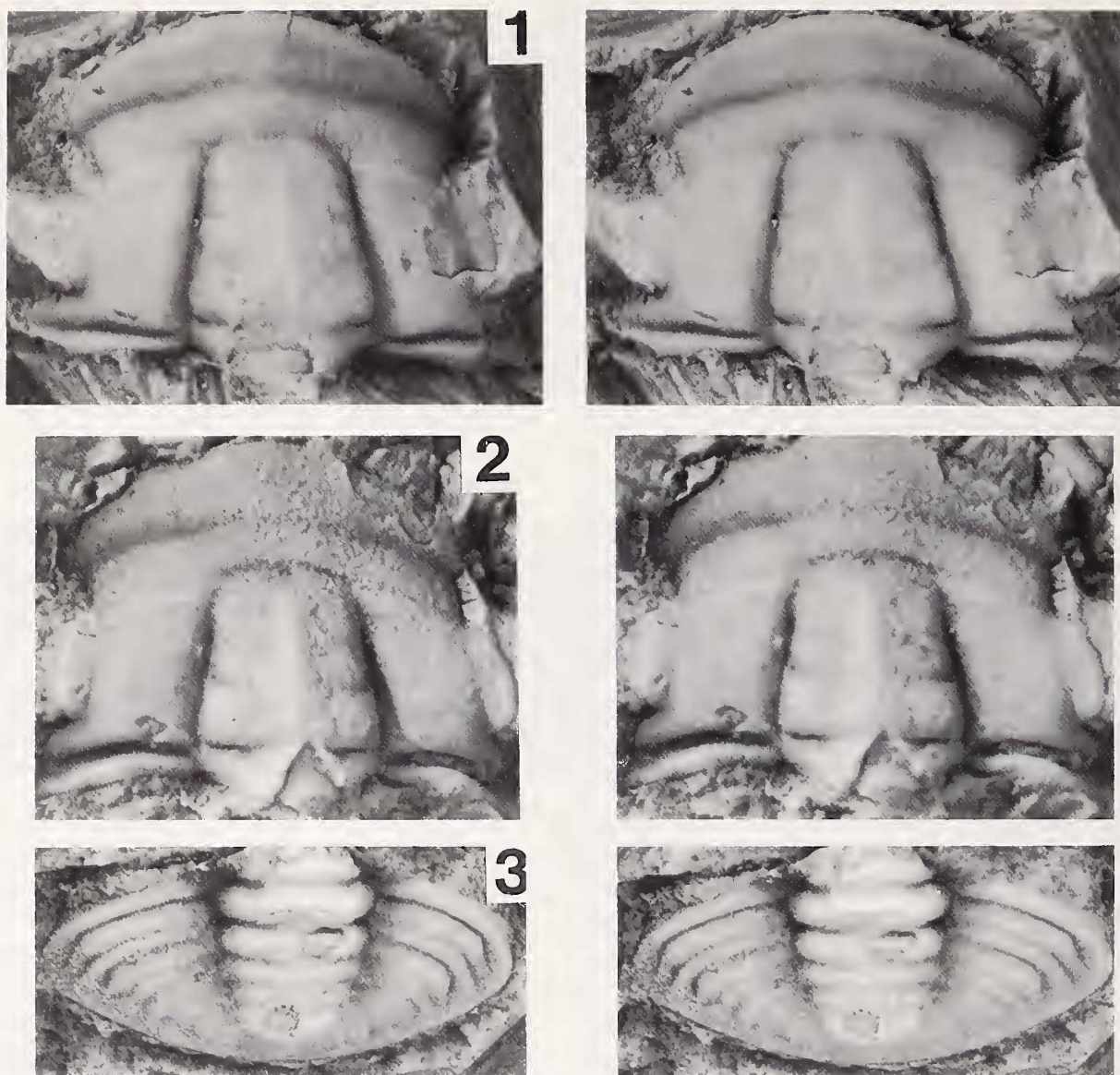


Figure 34. *Ehmaniella fronsplanata fronsplanata*, new species and subspecies, LACMIP locality 15483. 1, Stereo pair of holotype cranium (LACMIP 11818), slightly exfoliated, $\times 6.4$. 2, Stereo pair of paratype cranium (LACMIP 11817), slightly exfoliated, $\times 7.7$. 3, Stereo pair of paratype pygidium (LACMIP 11821), not exfoliated, $\times 9.9$.

convex or concave, elongate medial swelling present or absent, downsloping, tapering laterally, evenly curved, sagittal length 55–65% frontal area length. Anterior border furrow evenly curved, moderate depth laterally, shallow medially, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 50–60% glabellar width, low convexity, level to upsloping. Palpebral lobe weakly crescent shaped, narrow to moderately wide, width 25–40% lobe length, upsloping; moderate length, length 35–50% glabellar length; anterior margin located adjacent to 15–30% glabellar length from anterior margin of frontal lobe; furrow moderate depth to shallow medially. Ocular ridge moderate strength, directed moderately posterolaterally from glabella at 70–75° to axial trend. Posterior area of fixigena exsagittal width 25–35% glabellar length; length 55–70% glabella length; sharply terminated. Posterior border strongly convex, slightly wider distally; border furrow narrow, deep, straight, slightly wider laterally.

Librigena small, length 2.4–4.2 mm; moderately narrow, width 35–45% length without spine; lateral margin moderately curved. Genal field moderately convex, width 25–40% librigenal width. Border with approximately 40% librigenal width, uniform thick-

ness; moderately to strongly convex to flat; lateral border furrow moderately deep, slightly shallowing anteriorly and posteriorly; posterior border furrow moderate depth, slightly shallowing laterally. Genal spine moderate length, 45–60% librigenal length.

Hypostoma fused with rostrum; small, length 1.1 mm; subtriangular, length approximately 140% width, moderate convexity (sag. and trans.); anterior margin slightly curved; lateral margins smooth, parallel; posterior margin strongly curved. Median body moderately convex (sag. and trans.); suboval shaped; macula not evident. Posterior lobe wide, moderately low convexity; furrow moderate depth laterally, absent medially. Anterior border not defined, fused with rostral plate; border furrow absent. Lateral borders well defined, narrow, approximately 10% of hypostoma width; convex, moderate depth border furrow. Posterior border narrow, approximately 5% hypostoma length, moderately convex; border furrow narrow, moderate depth. Rostral plate strongly convex; narrow medially, approximately 5% hypostoma length, wider slightly and downsloping laterally, projecting slightly posterolaterally.

Thorax moderate length, 12 or more segments (specimen incomplete). Axis well defined by deep

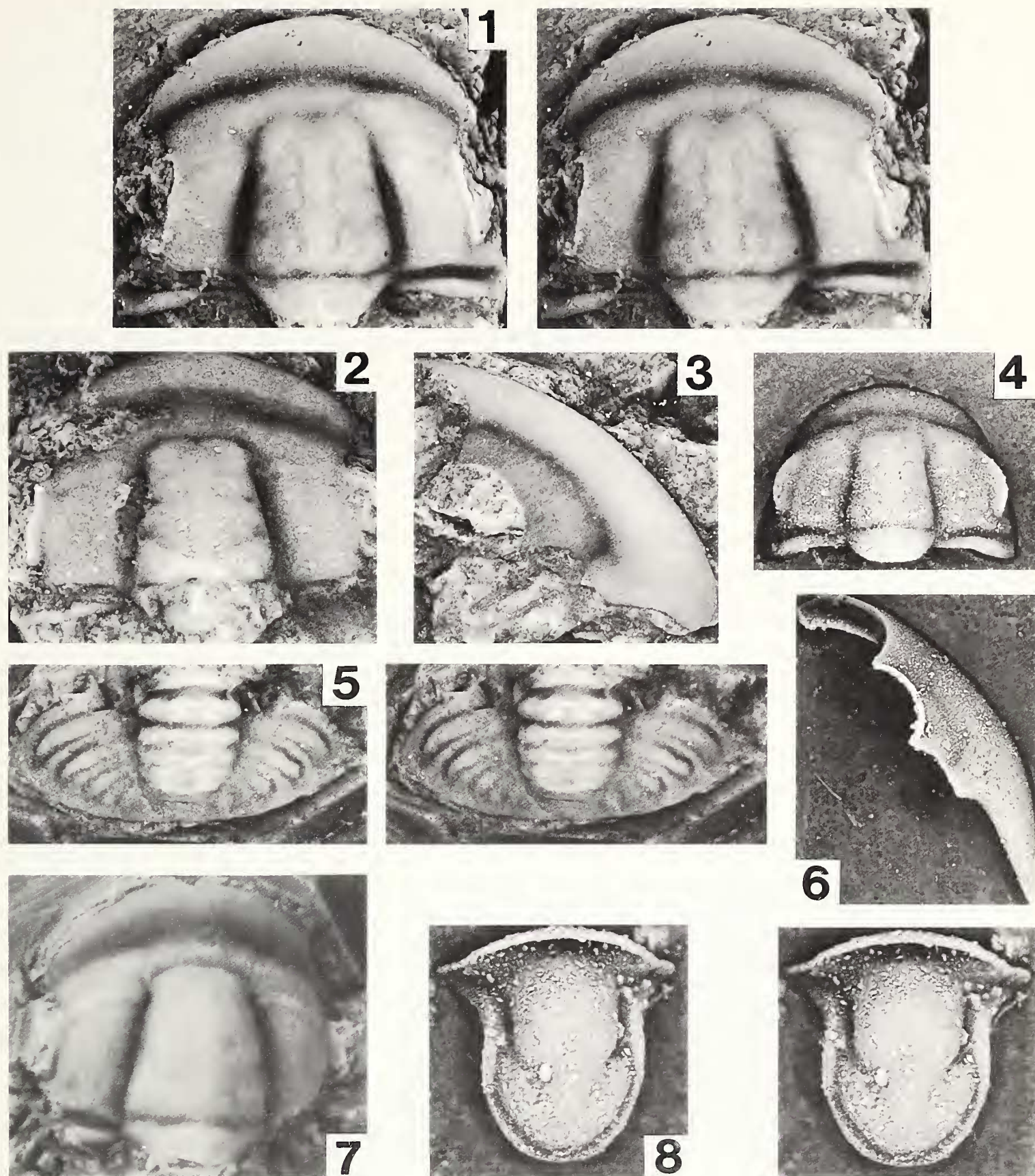


Figure 35. *Ehmaniella fronsplanata convexa*, new species and subspecies. 1, Stereo pair of holotype cranidium (LACMIP 11812), LACMIP locality 15478, not exfoliated, $\times 11.0$. 2, Partial paratype cranidium (LACMIP 11807), LACMIP locality 15477, not exfoliated, $\times 13.1$. 3, Paratype free cheek (LACMIP 11813), LACMIP locality 15478, exfoliated, $\times 9.4$. 4, Small, silicified paratype cranidium (LACMIP 11803), LACMIP locality 15476, coated with ammonium chloride, $\times 7.3$. 5, Stereo pair of paratype pygidium (LACMIP 11814), LACMIP locality 15478, exfoliated, $\times 9.2$. 6, Silicified paratype free cheek (LACMIP 11805), LACMIP locality 15476, coated with ammonium chloride, $\times 13.9$. 7, Partial large paratype cranidium (LACMIP 11810), LACMIP locality 15477, exfoliated, $\times 6.4$. 8, Stereo pair of silicified paratype hypostoma (LACMIP 11806), LACMIP locality 15476, coated with ammonium chloride, $\times 28.0$.

axial furrow, strongly convex, moderate width, strongly tapered. Pleura nearly equal length, bluntly terminated, projected laterally, posterior pleura directed slightly posteriorly; pleural furrow deep, narrow, widening laterally, parallel to margin; pleura lobes strongly convex.

Pygidium small, length 1.7–2.1 mm; alate, length 40–50% width; margin smooth, anterior margin slightly curved posteriorly; lateral margins evenly curved; posterior margin slightly flattened; moderate convexity (sag. and trans.), height 25–45% width. Axis slightly tapered, axial mid-width 85–

95% axial anterior width, axial anterior width 30–35% pygidial width; axial length 80–85% pygidial length, no postaxial ridge; 4 axial rings, high convexity; terminal axial piece strongly rounded; axial furrow shallow; axial ring furrows moderate to shallow depth, deeper laterally. Pleural regions well defined, sagittally elongate, triangularly shaped; low convexity, downsloping; anterior pleural furrow narrow, moderately deep, extends to margin, curved strongly posterior; 3 additional pleural furrows, moderate depth to shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows near border; anterior and posterior pleural bands moderately convex. Border narrow, width 5–10% pygidial length, slightly widening laterally; flat, level; border furrow absent.

Exoskeleton thin; very faint genal caeca on preglabellar field and anterior area of fixigena; fine granules on cranidia present or absent; scattered granules on fixigena present or absent. Other parts are smooth on external surface and internal mold.

REMARKS. *Ehmaniella fronsplanata* differs from other *Ehmaniella* species in having a smooth or nearly smooth exoskeleton; a very bluntly rounded frontal lobe; a tapered, less convex anterior border; and/or an alate pygidium. Two types of pygidia are associated with cranidia of two subspecies of *E. fronsplanata*. The pygidial type selected to be associated with *E. fronsplanata* is the more common of the two types and possesses a relatively sagittally narrow length and longer axis. The other associated pygidium (*Ehmaniellinae* sp. B; see Fig. 57) has a short blunt axis and is sagittally longer. It is possible that this pygidial type belongs to *E. fronsplanata* instead of or in addition to the long-axis pygidial type described above.

Three subspecies are recognized based on differences in the anterior border and ornamentation.

ETYMOLOGY. Latin, *frons* = front, *planus* = flat for the flat or slightly convex anterior border.

HOLOTYPE. Cranidium (LACMIP 11818) from the Swasey Limestone, Drum Mountain, Utah (LACMIP locality 15483).

PARATYPES. See subspecies.

OTHER MATERIAL. See subspecies.

OCCURRENCE. *Ehmaniella* Subzone, *Ehmaniella* Biozone. Whirlwind Formation, House Range, Utah. Swasey Limestone, Drum Mountain, Utah. Pole Canyon Limestone, Member E, Snake Range, Nevada.

Ehmaniella fronsplanata *fronsplanata*, new subspecies

Figure 34

DIAGNOSIS. *Ehmaniella fronsplanata* with cranidium with flat to very slightly convex anterior border, no medial swelling; smooth exoskeleton.

REMARKS. *Ehmaniella fronsplanata fronsplanata* differs from *E. fronsplanata convexa* in having a flat anterior border and smooth exoskeleton.

Ehmaniella fronsplanata fronsplanata differs from *E. fronsplanata convexa* in having a flat anterior border, no slight elongate medial swelling on the anterior border, and a slightly convex border of the librigena.

HOLOTYPE. Cranidium (LACMIP 11818) from the Swasey Limestone, Drum Mountain, Utah (LACMIP locality 15483).

PARATYPES. LACMIP 11816, 11817, 11819–11821 from LACMIP locality 15483.

OTHER MATERIAL. LACMIP locality 15483, 37 cranidia, 5 librigenae; LACMIP locality 15484, 24 cranidia; LACMIP locality 15485, 1? cranidium; LACMIP locality 15486, 1 cranidium; LACMIP locality 15513, 5? cranidia, 3? pygidia, 1? librigena.

OCCURRENCE. *Ehmaniella* Subzone, *Ehmaniella* Biozone. ?Whirlwind Shale, House Range, Utah. Swasey Limestone, Drum Mountain, Utah.

Ehmaniella fronsplanata *convexa*, new subspecies

Figure 35

DIAGNOSIS. *Ehmaniella fronsplanata* with cranidium with moderately convex anterior border, fine granular ornamentation, no medial swelling; scattered coarse granules on fixigena.

REMARKS. *Ehmaniella fronsplanata convexa* differs from *E. fronsplanata fronsplanata* as stated above. *Ehmaniella fronsplanata convexa* differs from *E. fronsplanata concava* in having a convex anterior border, no slight elongate medial swelling on anterior border, and convex border of the librigena. *Ehmaniella fronsplanata convexa* is the stratigraphically lowest subspecies of the three subspecies. It is also known by silicified cranidia, librigenae with eyes still attached, hypostoma, pleural segments, and pygidia.

ETYMOLOGY. Latin, for its convex anterior border.

HOLOTYPE. Cranidium (LACMIP 11812) from the Swasey Limestone, Drum Mountain, Utah (LACMIP locality 15478).

PARATYPES. LACMIP 11803–11806 from LACMIP locality 15476; LACMIP 11807–11811 from LACMIP locality 15477; LACMIP 11813–11815 from LACMIP locality 15478.

OTHER MATERIAL. LACMIP locality 15476, 5 cranidia, 4 librigenae; LACMIP locality 15477, 14 cranidia, 1 librigena; LACMIP locality 15478, 1 cranidium; LACMIP locality 15479, 1 librigena.

OCCURRENCE. *Ehmaniella* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountain, Utah.

Ehmaniella fronsplanata *concava*, new subspecies

Figure 36

DIAGNOSIS. *Ehmaniella fronsplanata* with cranidium with moderately concave anterior border,

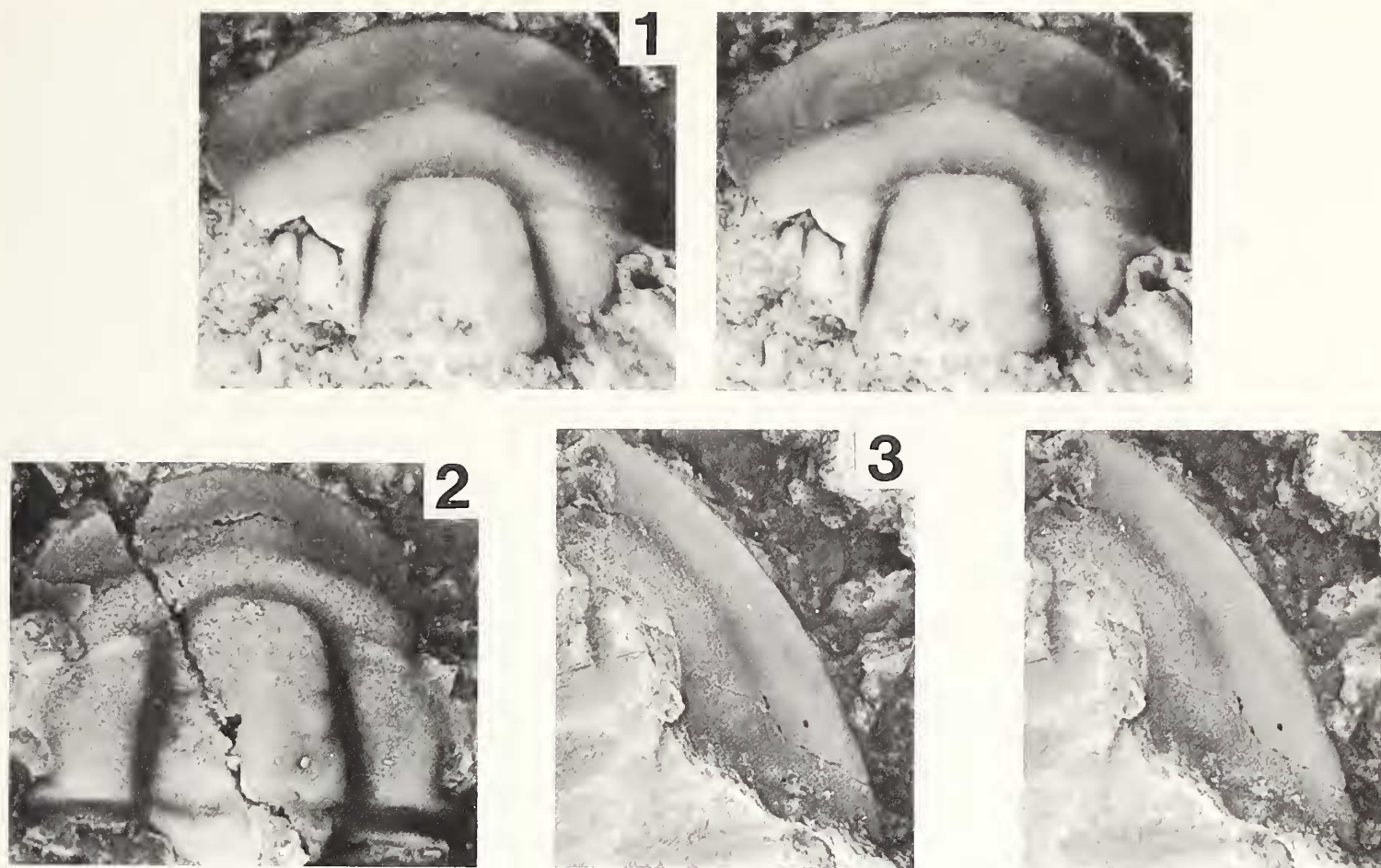


Figure 36. *Ehmaniella fronsplanata concava*, new species and subspecies, LACMIP locality 15480. 1, Stereo pair of partial paratype cranium (LACMIP 11802), exfoliated, $\times 7.6$. 2, Holotype cranium (LACMIP 11799), exfoliated, $\times 6.9$. 3, Stereo pair of paratype free cheek (LACMIP 11801), exfoliated, $\times 6.7$.

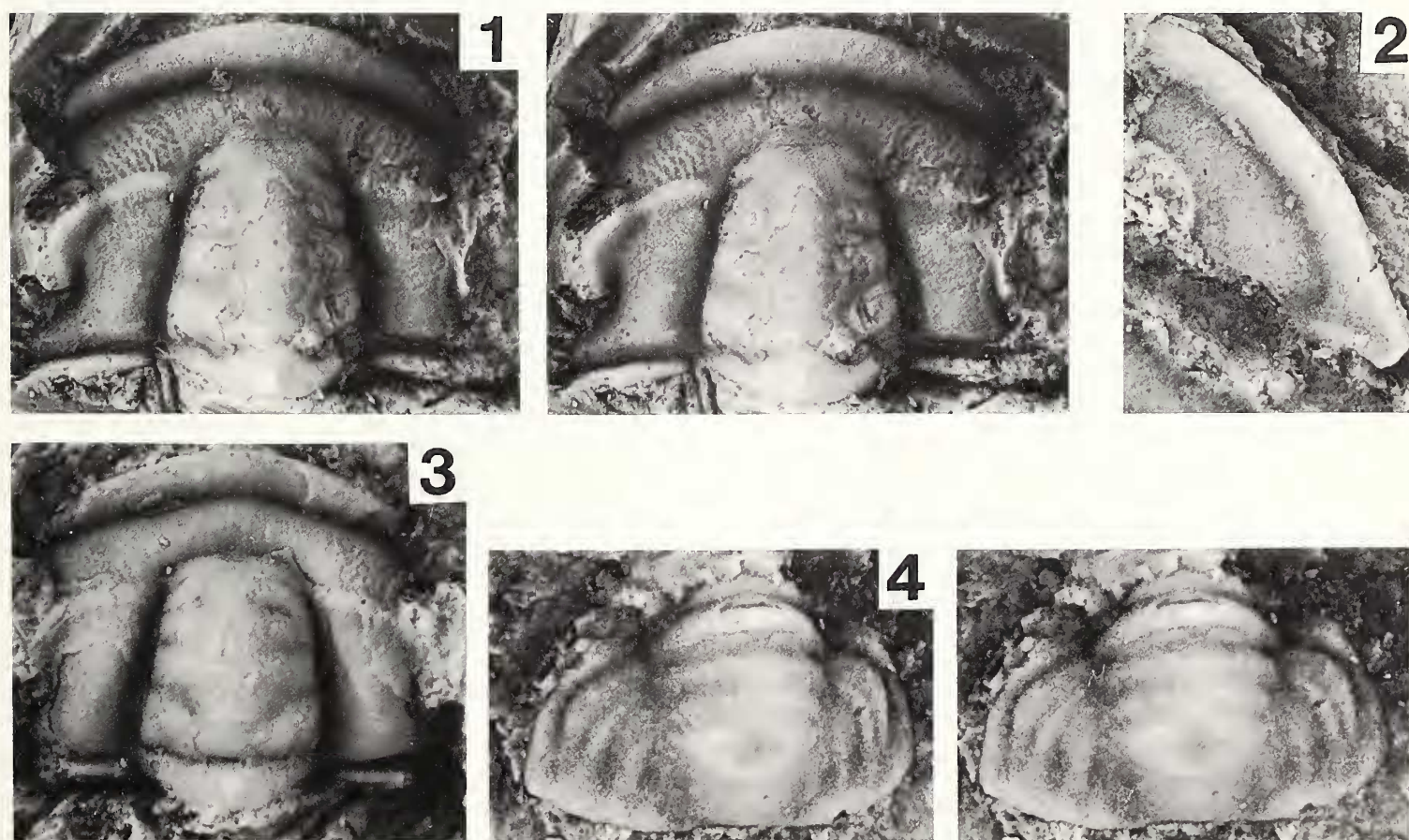


Figure 37. *Ehmaniella waptaensis* Rasetti, LACMIP locality 15512. 1, Stereo pair of cranium (LACMIP hypotype 11992), partially exfoliated, $\times 3.9$. 2, Small free cheek (LACMIP hypotype 11994), exfoliated, $\times 14.9$. 3, Cranium (LACMIP hypotype 11993), partially exfoliated, $\times 4.7$. 4, Stereo pair of pygidium (LACMIP hypotype 11995), not exfoliated, $\times 15.7$.

elongate medial swelling on anterior border, fine granular ornamentation.

REMARKS. *Ehmaniella fronsplanata concava* differs from *E. fronsplanata fronsplanata* and *E. fronsplanata convexa* as stated above. *Ehmaniella fronsplanata concava* is represented by fragmentary specimens; no pygidia are associated with the subspecies.

ETYMOLOGY. Latin, for its concave anterior border.

HOLOTYPE. Cranidium (LACMIP 11799) from the Swasey Limestone, Drum Mountain, Utah (LACMIP locality 15480).

PARATYPES. LACMIP 11800–11802 from LACMIP locality 15480.

OTHER MATERIAL. LACMIP locality 15480, 5 cranidia; LACMIP locality 15481, 4 cranidia; LACMIP locality 15482, 5 cranidia; LACMIP locality 15554, 4 cranidia.

OCCURRENCE. *Ehmaniella* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountain, Utah. Pole Canyon Limestone, Member E, Snake Range, Nevada.

Ehmaniella waptaensis

Rasetti, 1951

Figure 37

Ehmaniella waptaensis Rasetti, 1951:219–220, pl. 30, figs. 6–8; Sundberg, 1991:388, fig. 2.18.

Ehmaniella weedensis Hu (in part), 1986:7–9, pl. 13, figs. 11, 15, 19, 22–24.

EMENDED DIAGNOSIS. *Ehmaniella* with cranidium with bluntly rounded frontal lobe; fine granular ornamentation; strongly convex, moderately curved, upturned, slightly tapered, narrow anterior border (40–55% of frontal area length); moderately wide fixigenae (40–50% glabellar width). Pygidium subrectangular, blunt axis, weakly to moderately convex anterior pleural bands.

EMENDED DESCRIPTION. Cranidium moderate size, length 5.4–9.4 mm; rectangular, length 65–80% width; moderate sagittal and low transverse convexity, height 25–40% width; anterior margin moderately curved, anterior margin width 70–95% cranial width; posterior margin, excluding occipital ring, slightly backswept. Facial sutures slightly divergent from ends of palpebral lobes to middle of anterior border; convergent moderately strong across anterior half of border; strongly divergent posterior of palpebral lobes. Glabella well defined with deep axial furrows; elongate, length 70–75% and width 50–60% cranial length; glabella width 40–45% cranial width; moderately tapered, width at anterior end 75–85% glabellar width; moderate convexity (sag. and trans.); anterior end bluntly rounded to slightly flattened, 5 lateral glabellar lobes. Axial furrows deep, deeper posteriorly, straight to slightly convex; preglabellar furrow shallow, shallowing medially, moderately curved; lateral glabellar furrows shallow, F1 furrow bifurcated, directed posteriorly, F2 furrow directed

laterally, F3 and F4 furrows very shallow, directed slightly anteriorly. Occipital ring sagittal length approximately 20% glabellar length, not elevated above glabella and low convexity; small occipital node; furrow curved anteriorly, deep lateral, shallow medially; posterior margin curved. Frontal area length 20–30% cranial length, subequally divided. Preglabellar field slightly convex, moderately downsloping, length 45–60% frontal area length. Anterior border strongly convex, upsloping, slightly tapering laterally, evenly curved, sagittal length 40–55% frontal area length. Anterior border furrow evenly curved, deep laterally, shallowing medially, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, moderately narrow, 40–50% glabellar width, low to moderately low convexity, level. Palpebral lobe crescent shaped, narrow, width 20–30% lobe length, upsloping; long, length 35–40% glabellar length; anterior margin located adjacent to 20–25% glabellar length from anterior margin of frontal lobe; furrow moderate depth to shallow medially. Ocular ridge strong, directed slightly posterolaterally from glabella at 75–80° to axial trend. Posterior area of fixigena exsagittal width 25–35% glabellar length; length 50–60% glabella length; sharply terminated. Posterior border strongly convex, slightly wider distally; border furrow narrow, deep, straight, slightly wider laterally.

Librigena moderate size, length 2.2 mm; outline moderately wide, width 45–50% length without spine; lateral margin moderately curved. Genal field slightly convex, width approximately 45% librigenal width. Border width approximately 35% librigenal width; strongly convex; lateral border furrow moderate depth, uniform depth; posterior border furrow moderately shallow. Genal spine short.

Hypostoma unknown.

Thirteen thoracic segments, moderate length, approximately 53% shield length. Pleura transversely long, sagittally moderately wide, roundly terminated. Pleural furrow wide, moderate depth. Pleural lobes moderately convex. Axis wide, 85–90% pleural transverse length, tapering.

Pygidium small, length 0.9–2.4 mm; subrectangular, length 45–50% width; outline subrectangular, length 45–50% width; margin smooth, anterior margin strongly curved posteriorly; lateral margins evenly curved; posterior margin flattened to slightly curved; moderate convexity (sag. and trans.), height 30–45% width. Axis slightly tapered, axial mid-width 90–95% axial anterior width, axial anterior width 40–45% pygidial width; axial length 75–90% pygidial length, no postaxial ridge; 3–4 axial rings, high convexity; terminal axial piece strongly rounded; axial furrow shallow; axial ring furrows moderate to shallow depth, deeper laterally. Pleural regions well defined, sagittally elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, moderate depth, extends to margin, curved strongly posterior; 2 additional pleural furrows, moderate depth to shallow; inter-

pleural furrows moderate depth to shallow, joining with pleural furrows near border; anterior pleural bands moderately to weakly convex and developed; posterior pleural bands moderately convex. Border narrow, width 5–25% pygidial length, slightly widening laterally; flat, slightly upturned; no border furrow.

Exoskeleton thin; genal caeca on preglabellar field and anterior area of fixigena on external surface and internal mold; abundant, very fine granules on glabella, anterior border, and posterior portion of fixigena on external surface and internal mold of glabella. All other surfaces smooth.

REMARKS. This emended description of *Ehmaniella waptaensis* is based primarily on the unflattened, disarticulated specimens from the Whirlwind Formation instead of the flattened, complete exoskeletons from Burgess Shale. Unlike the specimens from the Burgess Shale, the specimens from the Whirlwind Formation show a narrower transverse width of the glabella and a F4 glabellar furrow. These differences probably resulted from the compression of the Burgess Shale specimens.

Ehmaniella waptaensis differs from *E. quadrans* in its granular ornamentation on the cranidium and a subrectangular pygidium and weaker anterior and posterior pleural bands (comparison based on the figured specimens of Palmer [1954:pl. 17, figs. 1–5]).

Several of the illustrated specimens of *E. weedensis* Hu, 1986, are *E. waptaensis*. The remaining illustrated specimens, including the holotype, do not belong to *Ehmaniella* or are too small to be assigned with any certainty. The specimens illustrated by Hu (1986:pl. 10) as *E. waptaensis* are either *Spencella* (figs. 16–18, 26), an ehmaniellid similar to *Ehmaniella fronsplanata* (figs. 19, 20, 27), or too small for taxonomic assignment.

HYPOTYPES. LACMIP 11992–11995 from LACMIP locality 15512.

OTHER MATERIAL. LACMIP locality 15472, 4 cranidia, 1 pygidium; LACMIP locality 15473, 2 cranidia, 1 pygidium; LACMIP locality 15475, 49 cranidia, 1 pygidium; LACMIP locality 15512, 38 cranidia, 1 pygidium.

OCCURRENCE. *Ehmaniella* Subzone, *Ehmaniella* Biozone. Stephen Formation, British Columbia (Rasetti, 1951). Whirlwind Formation, House Range and Drum Mountain, Utah.

Genus *Elrathiella* Poulsen, 1927

TYPE SPECIES. *Elrathiella obscura* Poulsen, 1927.

EMENDED DIAGNOSIS. Ehmaniellinae with subrectangular cranidium with divergent facial sutures anterior of palpebral lobes, moderate to long palpebral lobes (30–45% glabellar length); well-defined anterior border, narrow to moderate width (10–20% cranidial length), moderately to strongly tapered; preglabellar field sagittally moderately wide (25–45% frontal area length); moderately to strong-

ly tapered glabella; moderately to strongly rounded frontal lobe; exsagittally narrow posterior area of fixigenae (20–35% glabellar length). Pygidium subrectangular to subelliptical to subtriangular with elongate axis; 4–6 axial rings; moderate depth pleural furrows; moderately to strongly convex posterior pleural bands; moderate to absent anterior pleural bands.

REMARKS. *Elrathiella* can be distinguished from *Ehmaniella* in having a moderately to strongly rounded frontal lobe, larger specimens having a more strongly tapered glabella, more laterally tapered anterior border, and more axial rings. *Elrathiella* can be distinguished from *Elrathia* in having a stronger rounded frontal lobe, non-effaced lateral glabellar furrows, and non-alate pygidium. *Elrathiella* differs from *Proehmaniella* in having longer palpebral lobes, narrower (trans.) anterior border, narrower (exsag.) posterior area of fixigenae, more rounded frontal lobe, non-alate pygidium, and more axial rings. *Elrathiella domensa* is the earliest known species of the genus and is intermediate in morphology between species of *Elrathiella* and *Proehmaniella* in having a wider preglabellar field and less rounded frontal lobe. *Elrathiella* occurs in the middle and upper portions of the *Ehmaniella* Biozone.

Elrathiella decora Resser, 1945

Figure 38

Elrathiella decora Resser, 1945:209–210, pl. 24, fig. 1; Sundberg, 1991:388, fig. 2.17.

EMENDED DIAGNOSIS. *Elrathiella* with cranidium with elongated glabella (70–80% cranidial length), strongly tapered, strongly rounded frontal lobe; anterior border convex, wide (65–75% frontal area length), evenly curved, moderately to strongly tapered; shallow anterior border furrow; moderately wide fixigenae (50–60% glabellar width); coarse granular ornamentation. Pygidium subelliptical to subrectangular, smooth; anterior pleural bands moderately to weakly convex.

EMENDED DESCRIPTION. Cranidium moderate size, length 3.5–11.1 mm; subrectangular, length 65–70% width; moderate to moderately low convexity (sag. and trans.), height 20–25% width; anterior margin moderately, evenly curved, anterior margin width 70–80% cranidial width; posterior margin, excluding occipital ring, straight to slightly backswept. Facial sutures slightly to moderately divergent from ends of palpebral lobes to anterior border furrow; strongly convergent across anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 70–80% and width 50–55% cranidial length; glabella width 30–35% cranidial width; strongly tapered, width at anterior end 65–75% glabellar width; moderate to low convexity (sag. and trans.); frontal lobe strongly rounded, 4 lateral glabellar lobes. Axial furrows moderate depth to deep, deeper posteriorly, slightly concave

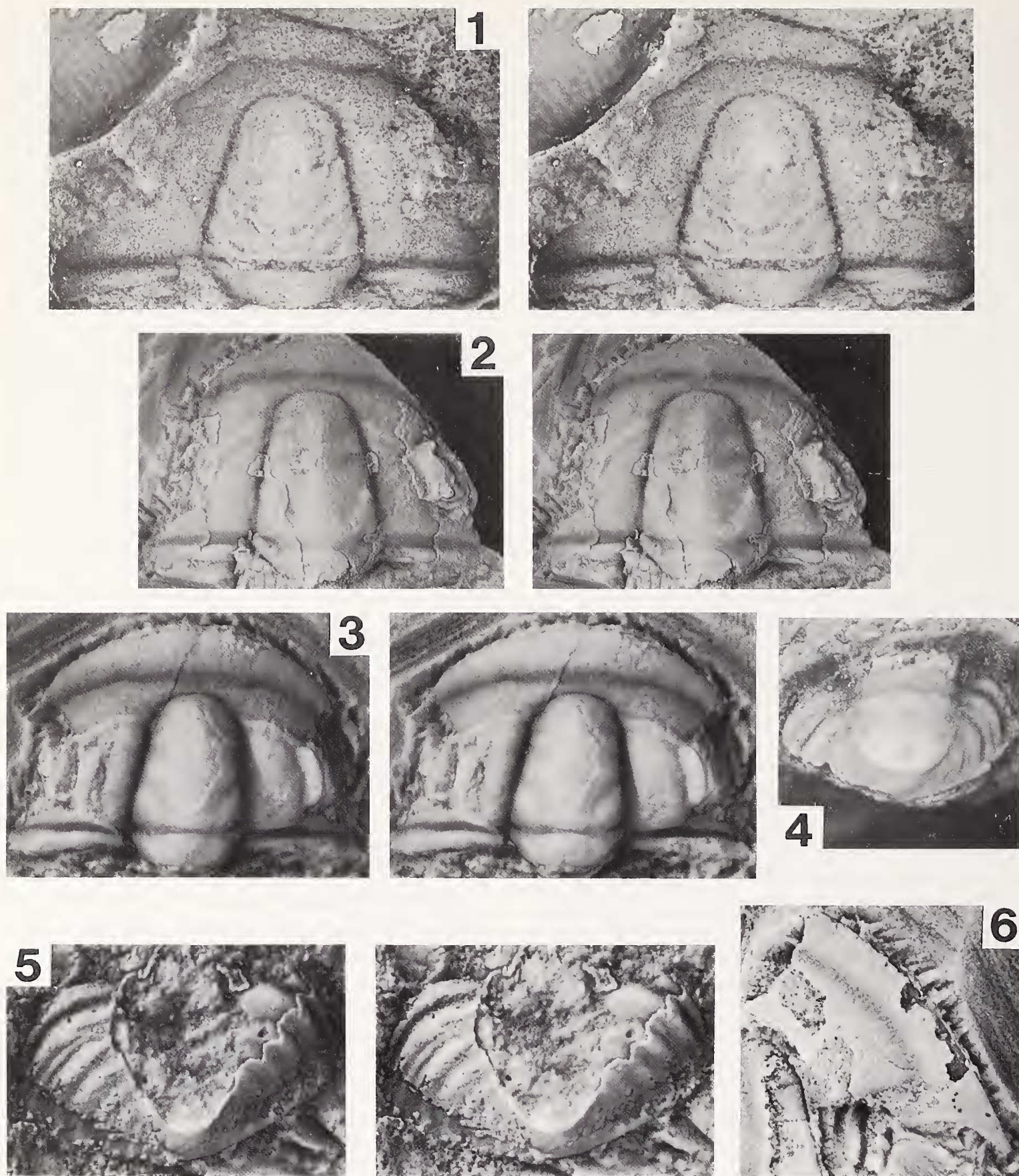


Figure 38. *Elrathiella decora* Resser. 1, Stereo pair of latex cast of holotype cranidium (USMN 108615a) in fine-grained sandstone, Resser's (1945) locality 37, Grand Canyon, not exfoliated, $\times 2.9$. 2, Stereo pair of cranidium (LACMIP hypotype 11996), LACMIP locality 15504, mostly exfoliated, $\times 2.9$. 3, Stereo pair of slightly flattened cranidium (LACMIP hypotype 11997), LACMIP locality 15506, partially exfoliated, $\times 4.8$. 4, Small pygidium (LACMIP hypotype 11999), LACMIP locality 15463, not exfoliated, $\times 14.4$. 5, Stereo pair of partially silicified pygidium (LACMIP hypotype 11998), LACMIP locality 15504, $\times 5.2$. 6, Partially silicified free cheek (LACMIP hypotype 12000), LACMIP locality 15504, $\times 5.4$.

to straight; preglabellar furrow moderate depth, moderately to strongly curved; lateral glabellar furrows shallow, F1 furrow bifurcated, directed posteriorly, F2 furrow directed posteriorly, F3 furrow directed slightly anteriorly. Occipital ring sagittal length 20–25% glabellar length, not elevated above glabella, moderately convex; small occipital node; furrow curved slightly anteriorly, deeper laterally,

shallowing medial, deep to moderate depth; posterior margin curved. Frontal area length 20–30% cranial length, unequally divided. Preglabellar field very slightly convex, moderately downsloping, length 25–35% frontal area length. Anterior border slightly to moderately convex, level, moderately to strongly tapering, evenly curved, sagittal length 67–75% frontal area length. Anterior border furrow

evenly curved, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 50–60% glabellar width, low to moderate convexity, level to slightly upsloping. Palpebral lobe moderately wide, width 30–40% lobe length; moderate length, length 35–45% glabellar length; anterior margin located adjacent to 20–30% glabellar length from anterior margin of frontal lobe; furrow moderate depth to shallow. Ocular ridge moderately strong, directed moderately posterolaterally from glabella at 65–75° to axial trend. Posterior area of fixigena exsagittal width 20–25% glabellar length; length 55–70% glabella length; sharply terminated. Posterior border high, strongly convex, distally wider; border furrow narrow, deep, straight, wider laterally.

Librigena small, width 1.1 mm; moderately wide; lateral margin moderately curved. Genal field gently convex, width approximately 65% librigenal width. Border with approximately 30% librigenal width; slightly convex; lateral border furrow moderately shallow, uniform depth; posterior border furrow shallow. Genal spine short.

Hypostoma and thorax unknown.

Pygidium small, length 1.3–4.8 mm; subelliptical to subrectangular, length 50–55% width; margin smooth, anterior margin strongly curved posteriorly; lateral margins slightly curved; posterior margin slightly curved; moderately low convexity (sag. and trans.), height approximately 45% width. Axis slightly tapered, axial mid-width approximately 90% axial anterior width, axial anterior width approximately 50% pygidial width; axial length approximately 75% pygidial length, low relief, postaxial ridge reaching border; 3 (or more?) axial rings, high convexity; terminal axial piece broadly rounded; axial furrow shallow; axial ring furrows moderately shallow, deeper laterally. Pleural regions well defined, sagittally elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, moderately deep, extends to margin, curved moderately posterior; 3–4 additional pleural furrows, moderate depth to shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows near margin; anterior pleural bands moderately to weakly convex and developed; posterior pleural bands moderately convex and developed. Border narrow, width approximately 10% pygidial length; flat, downsloping; border furrow absent.

Exoskeleton thin; faint to moderate strength genal caeca on preglabellar field, anterior area of fixigena, and genal field of librigena on external and internal surfaces; small cranidia with scattered granules on external surface and internal mold of cranidia; large cranidia with abundant granules on external surface and internal mold; pygidia smooth on external surface and internal mold.

REMARKS. The emended diagnosis and descriptions are based on the type specimens of Resser (1945) and the specimens collected for this study. *Elrathiella decora* is morphologically variable;

cranidia vary in the relative length of the glabella, convexity of the anterior border, width of preglabellar field, direction of the ocular ridge across the fixigena, granulation, and width of the fixigena. Most of these variations may be ontogenetic, smaller specimens have shorter glabellae, more convex anterior borders, more laterally directed ocular ridges, fewer granules, and wider fixigenae. However, part of this variation may be due to evolutionary changes within the species, because the larger specimens are found stratigraphically higher in the section. However, there is no clear separation between morphologies of the stratigraphically lower and smaller specimens and the stratigraphically higher and larger specimens. The size distribution of the specimens at different stratigraphic levels may be due to mechanical sorting and not genetic. Thus, the different groups of specimens are placed in one species. The three specimens from the Grand Canyon (Resser, 1945) have slightly wider preglabellar fields than the specimens from the study area.

The pygidium of this species is poorly known. Only two specimens are present in the collection; one is relatively large and fragmented, the other is small but complete.

Elrathiella decora is most similar to *E. euthyopsis*, new species, but differs in having a cranidium with a slightly convex, more curved, and evenly curved anterior border and a subtriangular pygidium with no granules, three to five axial rings, and shallower axial, axial ring, pleural, and interpleural furrows.

HYPOTYPES. LACMIP 11996 from LACMIP locality 15504; LACMIP 11997 from locality 15506; LACMIP 11998, 12000 from LACMIP locality 15504; LACMIP 11999 from LACMIP locality 15463.

OTHER MATERIAL. LACMIP locality 15463, 11 cranidia, 1 pygidium, 1 librigena; LACMIP locality 15464, 1 cranidium, 1 librigena; LACMIP locality 15504, 14 cranidia; LACMIP locality 15505, 2 cranidia; LACMIP locality 15506, 4 cranidia; LACMIP locality 15507, 2 cranidia.

OCCURRENCE. *Ehmaniella* Biozone. Bright Angel Shale?, Grand Canyon, Arizona (Resser, 1945). *Elrathiella* Subzone, *Elrathiella* Biozone. Whirlwind Formation, Drum Mountains and House Range, Utah.

Elrathiella domensa, new species

Figure 39

DIAGNOSIS. *Elrathiella* with cranidium with moderately elongate glabella (60–70% cranidial length), strongly tapered, strongly rounded frontal lobe; anterior border flat, moderately wide (55–65% frontal area length), evenly curved, slightly tapered; shallow anterior border furrow; moderately narrow fixigenae (40–55% glabellar width); very fine granular ornamentation. Pygidium subelliptical, smooth; anterior pleural bands weakly to moderately convex.

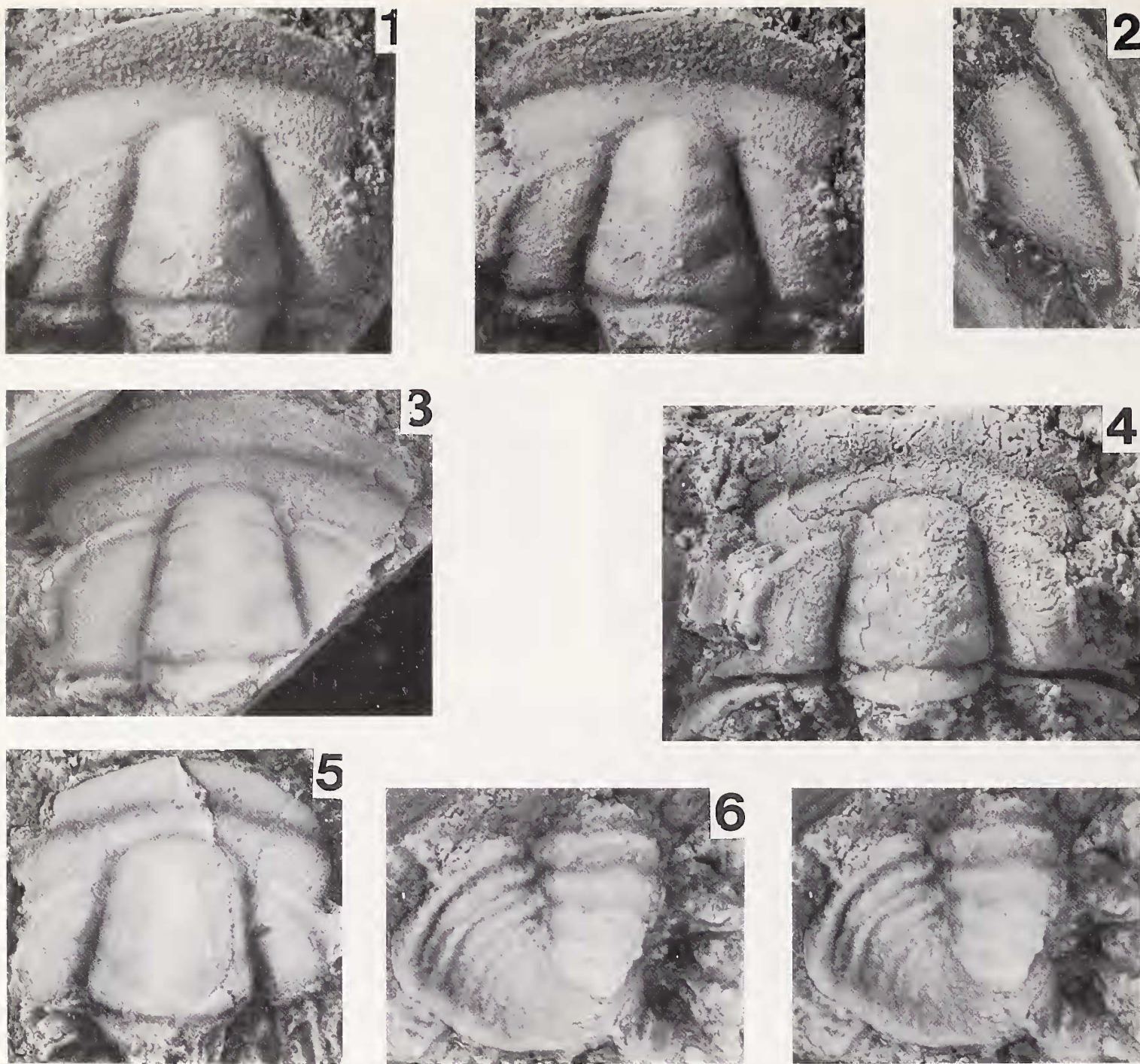


Figure 39. *Elrathiella domensa* new species. 1, Stereo pair of paratype cranidium (KUMIP 204733), RC locality 374, slightly exfoliated, $\times 5.6$. 2, Partial paratype free cheek (KUMIP 204734), RC locality 374, exfoliated, $\times 4.0$. 3, Holotype cranidium (KUMIP 204732), RC locality 374, slightly exfoliated, $\times 4.2$. 4, Paratype cranidium (KUMIP 204730), RC locality 211, mostly exfoliated, $\times 5.4$. 5, Partial paratype cranidium (KUMIP 204735) with convex anterior border, RC locality 374, exfoliated, $\times 5.5$. 6, Stereo pair of partial paratype pygidium (KUMIP 204737), RC locality 374, exfoliated, $\times 7.8$.

DESCRIPTION. Cranidium moderate size, length 4.0–8.8 mm; subrectangular, length 60–75% width; moderate convexity (sag. and trans.), height 25–40% width; anterior margin moderately curved, anterior margin width 65–70% cranidial width; posterior margin, excluding occipital ring, moderately backswept. Facial sutures moderately divergent from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 65–70% and width 50–55% cranidial length; glabella width 30–40% cranidial width; strongly tapered, width at anterior end 65–75% glabellar width; high convexity (sag. and trans.); frontal lobe strongly rounded, 3 (possibly 4) lateral glabellar lobes. Axial furrows

moderate depth, deeper posteriorly, slightly concave; preglabellar furrow moderate depth, moderately curved; lateral glabellar furrows shallow, F1 furrow bifurcated, directed posteriorly, F2 and F3 furrows directed laterally to slightly anteriorly, possible very shallow F4 furrow. Occipital ring sagittal length 15–20% glabellar length, slightly elevated above glabella, moderately convex; small occipital node; furrow curved anteriorly, deeper laterally, shallowing medial, deep to moderate depth; posterior margin curved. Frontal area length 25–30% cranidial length, subequally divided. Preglabellar field slightly convex, moderately downsloping, length 35–45% frontal area length. Anterior border flat to slightly convex, upsloping, slightly tapering laterally, evenly curved, sagittal length 55–65%

frontal area length. Anterior border furrow evenly curved with very weak medial inbend, shallow, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 40–55% glabellar width, low convexity, slightly upsloping. Palpebral lobe narrow, width 15–20% lobe length; long, length 40–45% glabellar length; anterior margin located adjacent to 25–30% glabellar length from anterior margin of frontal lobe; furrow shallow. Ocular ridge moderate strength to strong, directed moderately posterolaterally from glabella at 65–70° to axial trend. Posterior area of fixigena exsagittal width 20–25% glabellar length; length 70–75% glabella length; sharply terminated. Posterior border high, strongly convex, distally wider; border furrow narrow, deep, straight, wider laterally.

Librigena moderate size, length 12.1 mm; moderately wide, width approximately 60% length without spine; lateral margin moderately curved. Genal field gently convex, width approximately 60% librigenal width. Border width approximately 25% librigenal width; gently convex; lateral border furrow shallow, shallowing posteriorly; posterior border furrow shallow, shallowing laterally. Genal spine unknown.

Hypostoma and thorax unknown.

Pygidium small, length 3.2 mm; subtriangular, length 55% width; margin smooth, anterior margin strongly curved posteriorly; lateral margins slightly flattened; posterior margin slightly flattened; moderate convexity (sag. and trans.), height 45% width. Axis moderately tapered, axial mid-width 80% axial anterior width, axial anterior width 50% pygidial width; axial length 85% pygidial length, postaxial ridge reaching border; 5 axial rings, high convexity; terminal axial piece pointed; axial and axial ring furrows moderate depth, deeper laterally. Pleural regions well defined, transversely elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, moderately deep, extends to margin, curved strongly posterior; 4 additional pleural furrows, moderate depth to shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows near margin; anterior pleural bands slightly convex, poorly developed; posterior pleural bands moderately convex and developed. Border narrow, width 5% pygidial length; very slightly convex, downsloping; border furrow absent.

Exoskeleton thin; genal caeca on preglabellar field, anterior area of fixigena, and genal area of librigenae on external and internal surfaces; abundant, very fine granules on external surface of glabella; pygidial smooth on internal and external(?) surfaces.

REMARKS. *Elrathiella domensa* is most similar to *E. obscura* but differs in having more divergent anterior facial sutures and a stronger tapering anterior border. *Elrathiella domensa* differs from its coeval *Proehmaniella? granulosa*, new species, by its wider anterior border, genal caeca on the cranidium and librigenae, and suboval pygidium. *El-*

rathiella domensa differs from other *Elrathiella* species in its less rounded frontal lobe, wider frontal area, and flat anterior border. Smaller cranidia of *E. domensa* have more convex borders.

ETYMOLOGY. Latinized, named after the Dome Limestone.

HOLOTYPE. Cranidium (KUMIP 204732) from the Dome Limestone, House Range, Utah (RC locality 374).

PARATYPES. KUMIP 204730, 204731 from RC locality 211; KUMIP 204733–204737 from RC locality 374.

OTHER MATERIAL. RC locality 211, 10 cranidia, 1 pygidium; RC locality 374, 1 cranidium; LACMIP locality 15462, 2 cranidia.

OCCURRENCE. *Elrathiella* Subzone, *Ehmaniella* Biozone. Dome Limestone, House Range and Drum Mountains, Utah.

Elrathiella dugwayensa, new species

Figure 40

DIAGNOSIS. *Elrathiella* with cranidium with elongated glabella (75–80% cranidial length), moderately to strongly tapered, sharply rounded frontal lobe; anterior border strongly convex, moderately wide (55–65% frontal area length) unevenly curved, straight medially, moderately tapered; medially shallow to laterally moderate depth anterior border furrow; moderately narrow fixigenae (45–55% glabellar width). Pygidium subrectangular; anterior pleural bands weakly convex to absent.

DESCRIPTION. Cranidium moderate size, length 6.4–9.2 mm; subrectangular, length 55–65% width; moderate to moderately low convexity (sag. and trans.), height 20–30% width; anterior margin slightly curved, unevenly curved, straight medially, anterior margin width 60–70% cranidial width; posterior margin, excluding occipital ring, straight. Facial sutures moderately divergent from ends of palpebral lobes to anterior border furrow; strongly convergent across anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 75–80% and width 50–60% cranidial length; glabella width 30–35% cranidial width; strongly to moderately tapered, width at anterior end 65–80% glabellar width; high convexity (sag. and trans.); frontal lobe sharply rounded, 3 lateral glabellar lobes. Axial furrows very deep, uniform depth, very slightly convex; preglabellar furrow very shallow, strongly curved; lateral glabellar furrows shallow, F1 furrow bifurcated, directed posteriorly, F2 furrow directed slightly posteriorly; F3 furrow directed slightly anteriorly. Occipital ring sagittal length approximately 20% glabellar length, not elevated to slightly elevated above glabella, moderately convex; furrow straight, deep laterally, shallow medial, posterior margin straight. Frontal area length approximately 20% cranidial length, subequally divided. Preglabellar field very slightly convex, slight-

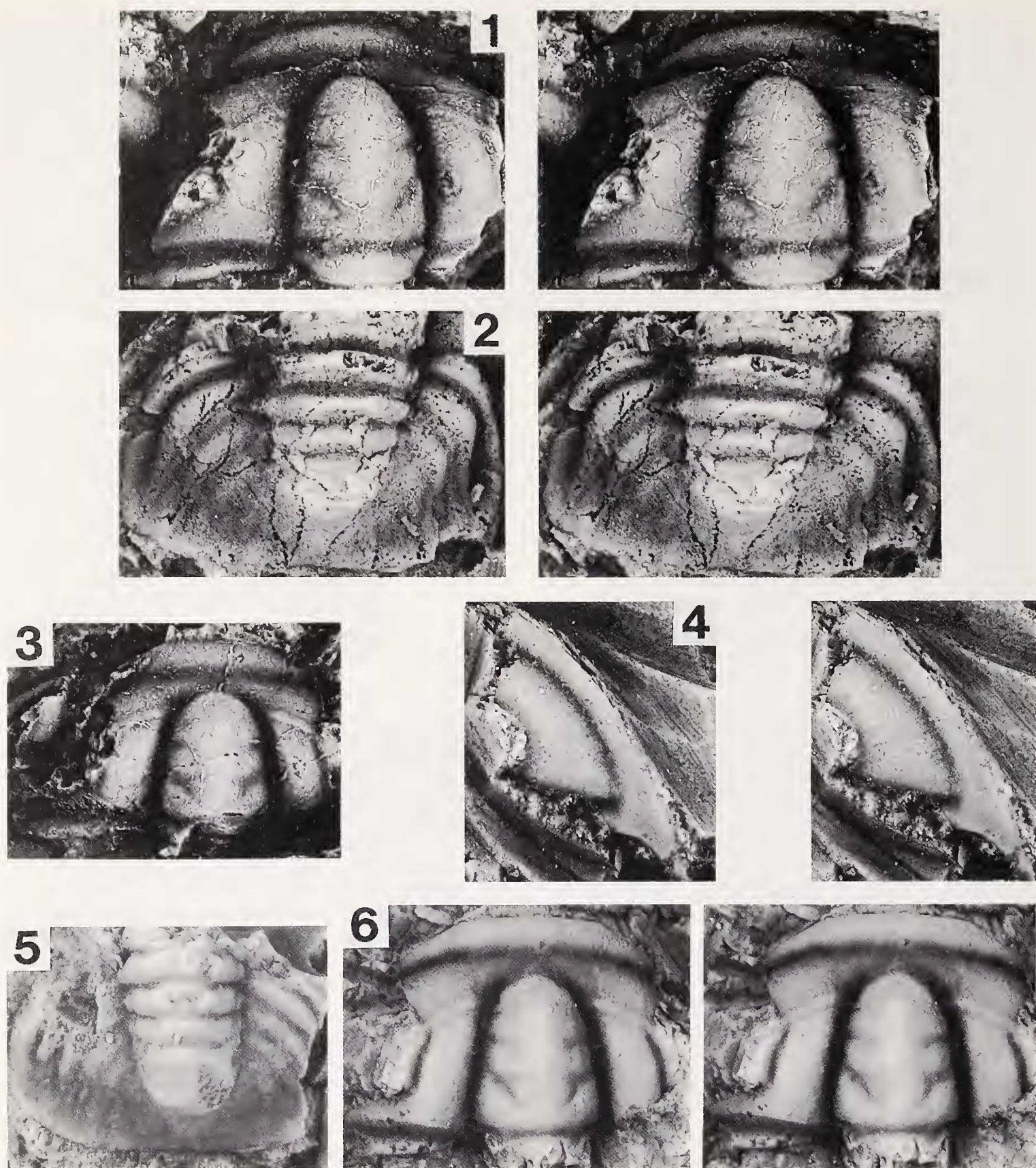


Figure 40. *Elrathiella dugwayensa*, new species. 1, Stereo pair of holotype cranidium (LACMIP 11825), LACMIP locality 15523, exfoliated, $\times 4.9$. 2, Stereo pair of paratype pygidium (LACMIP 11828), LACMIP locality 15523, exfoliated, $\times 9.0$. 3, Small paratype cranidium (LACMIP 11827), LACMIP locality 15523, exfoliated, $\times 4.2$. 4, Stereo pair of paratype free cheek (LACMIP 11824), LACMIP locality 15470, exfoliated, $\times 4.1$. 5, Paratype pygidium (LACMIP 11823), LACMIP locality 15470, exfoliated, $\times 9.4$. 6, Stereo pair of paratype cranidium (LACMIP 11822), LACMIP locality 15470, exfoliated, $\times 4.9$.

ly downsloping, length 35–45% frontal area length. Anterior border slightly to strongly convex, level, tapering laterally, unevenly curved, straight medially, sagittal length 55–65% frontal area length. Anterior border furrow unevenly curved, straight and shallow medially, moderate depth laterally, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 45–55% glabellar width, high convexity, upsloping. Palpebral lobe narrow, width

25–30% lobe length; moderate length, length 30–40% glabellar length; anterior margin located adjacent to 25–30% glabellar length from anterior margin of frontal lobe; furrow moderate depth. Ocular ridge moderately weak, very slightly arched, directed strongly posterolaterally from glabella at 65° to axial trend. Posterior area of fixigena exsagittal width 30–40% glabellar length; length 70–85% glabella length; sharply terminated. Posterior bor-

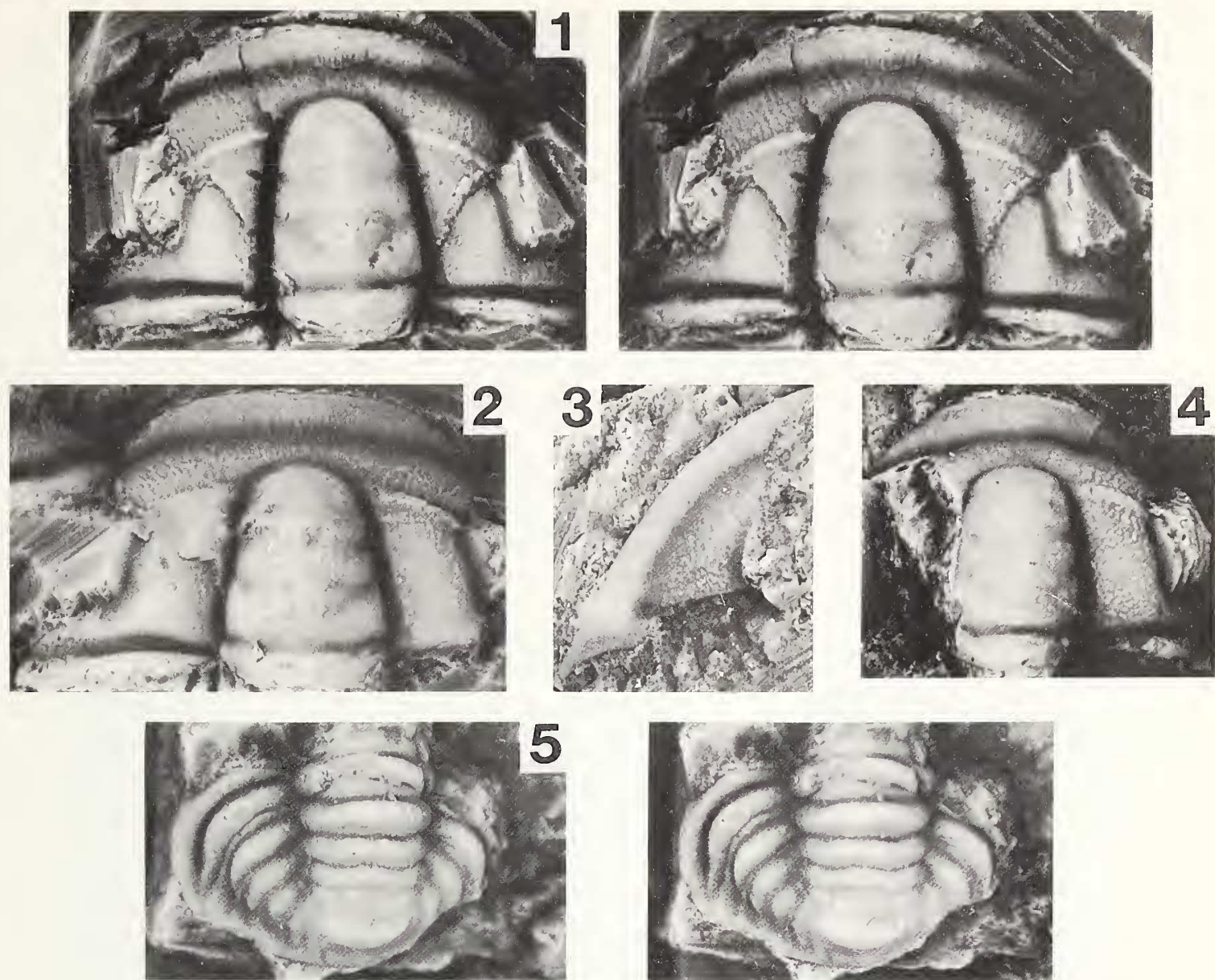


Figure 41. *Elrathiella euthyopsis*, new species, LACMIP locality 15465. 1, Stereo pair of holotype cranidium (LACMIP 11830), partially exfoliated, $\times 3.6$. 2, Partial paratype cranidium (LACMIP 11831), partially exfoliated, $\times 4.3$. 3, Paratype free cheek (LACMIP 11835), exfoliated, $\times 6.8$. 4, Stereo pair of partial, small paratype cranidium (LACMIP 11833), not exfoliated, $\times 7.4$. 5, Stereo pair of paratype pygidium (LACMIP 11834), not exfoliated, $\times 9.7$.

der high, moderately convex, distally wider; border furrow narrow, deep, straight, wider laterally.

Librigena moderate size, length 7.5 mm; moderately narrow, width approximately 50% length without spine; lateral margin slightly curved. Genal field moderately convex, width approximately 50% librigenal width. Border width approximately 25% librigenal width; moderately convex; lateral border furrow moderately deep, uniform depth; posterior border furrow moderately deep, furrows shallow at genal angle. Genal spine short, approximately 35% librigenal length.

Hypostoma and thorax unknown.

Pygidium small, length 2.7–3.2 mm; subrectangular, length 50–65% width; margin smooth, anterior margin moderately curved posteriorly; lateral margins evenly curved; posterior margin straight; moderately low convexity (sag. and trans.), height 35–55% width. Axis slightly tapered, axial mid-width 85–90% axial anterior width, axial anterior width 35–45% pygidial width; axial length 75–80% pygidial length, no postaxial ridge; 4 axial rings, high

convexity; terminal axial piece broadly rounded; axial furrow very shallow; axial ring furrows moderately shallow, deeper laterally. Pleural regions well defined, sagittally elongate, rectangular shaped; low convexity, downsloping; anterior pleural furrow narrow, moderately shallow, extends to border, curved moderately posterior; 3 additional pleural furrows, moderate depth to shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows near margin; anterior pleural bands very weakly developed or absent; posterior pleural lobes moderately developed and convex. Border not defined.

Exoskeleton unknown, all specimens exfoliated.

REMARKS. *Elrathiella dugwayensa* is most similar to *E. euthyopsis* but differs in its more rounded frontal lobe, curved anterior border, and subrectangular pygidium with weakly developed anterior pleural bands.

ETYMOLOGY. Latinized, named after the Dugway Range.

HOLOTYPE. Cranidium (LACMIP 11825) from

the Shadscale Formation, Dugway Range, Utah (LACMIP locality 15523).

PARATYPES. LACMIP 11822–11824 from LACMIP locality 15470; LACMIP 11826–11829 from LACMIP locality 15523.

OTHER MATERIAL. LACMIP locality 15471, 1? cranidium; LACMIP locality 15523, 9 cranidia, 1 pygidium.

OCCURRENCE. *Elrathiella* Subzone, *Ehmaniella* Biozone. Whirlwind Formation, Drum Mountains, Utah. Shadscale Formation, Dugway Range, Utah.

Elrathiella euthyopsis,
new species

Figure 41

DIAGNOSIS. *Elrathiella* with cranidium with elongate glabella (70–80% cranidial length), moderately to strongly tapered, strongly rounded frontal lobe; anterior border strongly convex, moderately wide (55–65% frontal area length) unevenly curved, nearly straight medially, moderately tapered; deep anterior border furrow; moderately wide fixigenae (55–60% glabellar width); moderately coarse granular ornamentation. Pygidium subelliptical, moderately coarse granular ornamentation; anterior pleural bands moderately to weakly developed.

DESCRIPTION. Cranidium moderate size, length 4.2–10.8 mm; subrectangular, length 55–60% (80%, see remarks) width; moderate to moderately low convexity (sag. and trans.), height 20–25% (55%) width; anterior margin slightly curved, nearly straight medially, anterior margin width 60–75% cranidial width; posterior margin, excluding occipital ring, straight. Facial sutures moderately divergent from ends of palpebral lobes to anterior border furrow; strongly convergent across anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 70–80% and width 50–55% cranidial length; glabella width 30–35% cranidial width; strongly tapered, width at anterior end 70–75% glabellar width; moderate convexity (sag. and trans.); frontal lobe strongly rounded, 4 lateral glabellar lobes. Axial furrows deep, deeper posteriorly, slightly concave to slightly convex; preglabellar furrow moderate depth, moderately to strongly curved; lateral glabellar furrows shallow, F1 furrow bifurcated, directed slightly posterior, F2 furrow directed very slightly posterior, F3 furrow directed slightly anteriorly, F4 absent to very shallow. Occipital ring sagittal length 15–25% glabellar length, not elevated above glabella, moderately low convexity; very small occipital node; furrow curved anteriorly, moderately deep laterally, shallowing medially, deep to shallow depth; posterior margin curved. Frontal area length 20–30% cranidial length, subequally divided. Preglabellar field slightly convex, moderately downsloping, length 35–45% frontal area length. Anterior border strongly convex,

level, slightly tapering laterally, nearly straight medially, sagittal length 55–65% frontal area length. Anterior border furrow nearly straight, deep and broad, slightly shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 55–60% glabellar width, moderate convexity, slightly upsloping. Palpebral lobe moderate width, width 20–45% lobe length, upsloping; moderate length, length 35–40% glabellar length; anterior margin located adjacent to 20–30% glabellar length from anterior margin of frontal lobe; furrow moderate depth. Ocular ridge moderately strong, directed moderately posterolaterally from glabella at 70° to axial trend. Posterior area of fixigena exsagittal width 25–30% glabellar length; length 75–85% (60%) glabella length; sharply terminated. Posterior border strongly convex, distally wider; border furrow narrow, deep, straight, wider laterally.

Librigena small, length 4.9 mm; relatively narrow, width approximately 40% length without spine; height 25–45% width; lateral margin moderately curved. Genal field gently convex, width 40–55% librigenal width. Border width 25–30% librigenal width; moderately convex; lateral border furrow moderate depth, uniform depth; posterior border furrow moderate depth. Genal spine short, approximately 25% librigenal length.

Hypostoma and thorax unknown.

Pygidium small, length 2.4 mm; subelliptical, length approximately 55% width; margin smooth, anterior margin strongly curved posteriorly; lateral margins slightly curved, nearly straight; posterior margin evenly curved; moderate convexity (sag. and trans.), height approximately 45% width. Axis slightly tapered, axial mid-width approximately 85% axial anterior width, axial anterior width approximately 40% pygidial width; axial length 85% pygidial length, no postaxial ridge; 5 axial rings, high convexity; terminal axial piece broadly rounded; axial furrow moderately shallow. Pleural regions well defined, sagittally elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, moderately deep, extends to margin, curved moderately posterior; 4 additional pleural furrows, moderate depth to moderately shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows near margin; anterior pleural bands moderate to weakly convex, moderately to poorly defined; posterior pleural bands moderately convex and well defined. Border narrow, width approximately 10% pygidial length; flat, level; border furrow absent.

Exoskeleton thin; faint to moderate strength genal caeca on preglabellar field, and anterior area of fixigena on external and internal surfaces; cranidia and pygidia with abundant, moderately coarse granules on external surface and internal mold of cranidia.

REMARKS. Larger specimens of *Elrathiella euthyopsis* are somewhat flattened; thus, the percentages presented above are approximate. The percentages in parentheses are based on a small

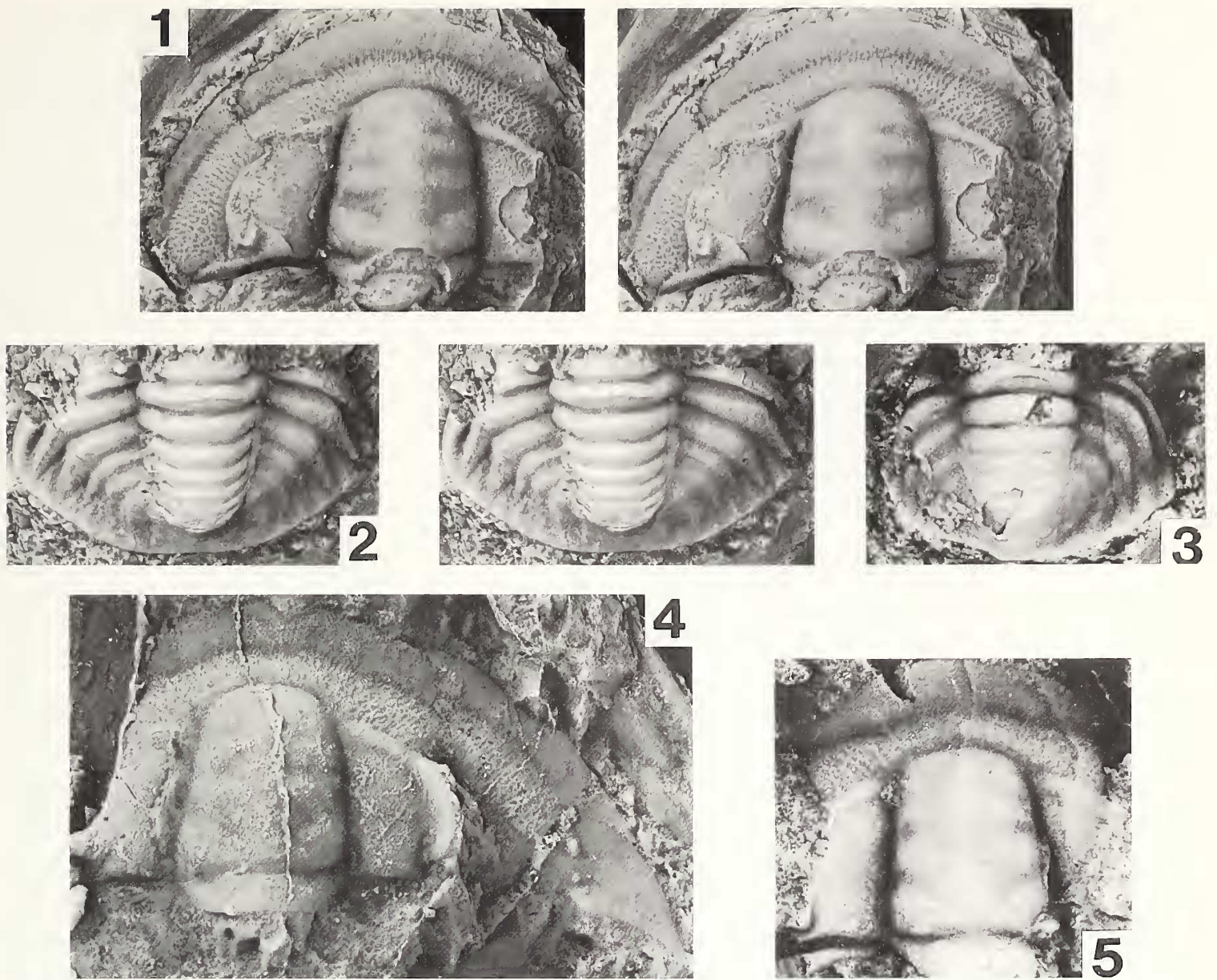


Figure 42. *Elrathiella? intermedia*, new species. 1, 4, Stereo pair and latex cast of holotype cranidium and right and left free cheeks (LACMIP 11840), LACMIP locality 15574, not exfoliated, $\times 3.9$; 4 is latex cast. 2, Stereo pair of large paratype pygidium (LACMIP 11839), LACMIP locality 15573, not exfoliated, $\times 3.6$. 3, Smaller paratype pygidium (LACMIP 11842), LACMIP locality 15574, slightly exfoliated, $\times 8.2$. 5, Partial paratype cranidium (LACMIP 11841), LACMIP locality 15574, exfoliated, $\times 6.2$.

specimen that is well preserved in a limestone (Fig. 41.4).

Elrathiella euthyopsis is most similar to *E. decora*, but differs in having a more convex, unevenly curved, and less tapering anterior border; wider anterior border furrow; wider preglabellar field; and pygidium with more axial rings, more posteriorly positioned lateral anterior corners, and granular ornamentation.

ETYMOLOGY. Greek, *euthys* = straight and *opsis* = appearance, for the nearly straight anterior margin of the cranidium.

HOLOTYPE. Cranidium (LACMIP 11830) from the Whirlwind Formation, Drum Mountains, Utah (LACMIP locality 15465).

PARATYPES. LACMIP 11831–11838 from LACMIP locality 15465.

OTHER MATERIAL. LACMIP locality 15465, 12 cranidia, 2 pygidia, 2 librigenae; LACMIP locality 15466, 35 cranidia, 1 librigena; LACMIP locality 15508, 3 cranidia.

OCCURRENCE. *Elrathiella* Subzone, *Ehmaniella* Biozone. Whirlwind Formation, Drum Mountains and House Range, Utah.

Elrathiella? intermedia,
new species
Figure 42

DIAGNOSIS. *Elrathiella?* with cranidium with elongated glabella (70–75% cranidial length), moderately tapered, moderately rounded frontal lobe; anterior border flat, moderately wide (55–65% frontal area length) evenly curved, very slightly tapered; shallow anterior border furrow; moderately wide fixigenae (50–55% glabellar width); fine granular ornamentation. Pygidium subelliptical, smooth; weakly developed anterior pleural bands.

DESCRIPTION. Cranidium moderate size, length 5.9–8.4 mm; rectangular, length 60–65% width; moderate convexity (sag. and trans.), height 20–25% width; anterior margin moderately curved, an-



Figure 43. *Elrathiella?* cf. *E? intermedia*, new species. Partial articulated specimen (USNM hypotype 468965), USGS locality 1982-CO, distorted, mostly exfoliated, $\times 3.8$.

terior margin width approximately 80% cranidial width; posterior margin, excluding occipital ring, straight to slightly backswept. Facial sutures moderately divergent from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 70–75% and width 50–55% cranidial length; glabella width 35–40% cranidial width; moderately tapered, width at anterior end 75–80% glabellar width; moderate convexity (sag. and trans.); frontal lobe bluntly rounded, 3 lateral glabellar lobes. Axial furrows moderately deep, deeper posteriorly, slightly concave; preglabellar furrow moderately shallow, shallower medially, moderately curved; lateral glabellar furrows shallow, F1 furrow bifurcated, directed slightly posteriorly, F2 and F3 furrows slightly anteriorly. Occipital ring sagittal length 15–20% glabellar length, slightly elevated above glabella, moderately convex; no occipital node; furrow slightly curved anteriorly, deeper laterally, shallowing medial, moderately deep to moderately shallow depth; posterior margin straight. Frontal area length 25–30% cranidial length, subequally divided. Preglabellar field slightly convex, moderately downsloping, length 35–45% frontal area length. Anterior border flat, level, very slightly tapering laterally, evenly curved, sagittal length 55–65% frontal area length. Anterior border furrow evenly curved, shallow, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 50–55% glabellar width, moderately low convexity, slightly upsloping. Palpebral lobe narrow, width 20–25% lobe length, length 40–55% glabellar length; anterior margin located adjacent to 25–35% glabellar length from anterior margin of frontal lobe; furrow shallow. Ocular ridge strong, directed moderately posterolaterally from glabella at 65–75° to

axial trend. Posterior area of fixigena exsagittal width 15–20% glabellar length; length 60–65% glabella length; sharply terminated. Posterior border high, strongly convex, distally wider; border furrow narrow, deep, curved slightly posteriorly, wider laterally.

Librigena moderate size, length 6.3–6.5 mm; relatively narrow, width 45–50% length without spine; height 40–60% width; lateral margin moderately curved. Genal field gently convex, width 40–45% librigenal width. Border width 25–30% librigenal width; flat; lateral border furrow moderately shallow, uniform depth; posterior border furrow shallow. Genal spine short, 25–30% librigenal length.

Hypostoma and thorax unknown.

Pygidium small to moderate size, length 2.7–5.9 mm; subelliptical to transversely elongate, length 55–65% width; margin smooth, anterior margin moderately to strongly curved posteriorly; lateral margins nearly straight; posterior margin straight; moderately high convexity (sag. and trans.), height 45–55% width. Axis slightly tapered, axial mid-width 85–90% axial anterior width, axial anterior width approximately 40% pygidial width; axial length 85–90% pygidial length, no postaxial ridge; 6 axial rings, high convexity; terminal axial piece rounded; axial furrows moderate depth; axial ring furrows moderate depth to deep, deeper laterally. Pleural regions well defined, transversely to sagittally elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, moderately deep, extends to margin, curved moderately to strongly posterior; 5 additional pleural furrows, moderate depth to very shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows near margin; anterior pleural bands weakly developed, short, near margin, weakly convex; posterior pleural bands well developed, moderately convex. Border narrow, width 6–7% pygidial length; very slightly convex, level; border furrow absent.

Exoskeleton thin; genal caeca on preglabellar field, anterior area of fixigena, and genal area of librigenae on external and internal surfaces; abundant, fine granules on external surface of glabella and posterior area of fixigena; pygidia smooth on external surface.

REMARKS. *Elrathiella? intermedia* is intermediate in morphology between the stratigraphically lower species of *Elrathiella* and the stratigraphically higher *Ehmaniella*. *Elrathiella? intermedia* is questionably assigned to the genus because of its moderately rounded frontal lobe, narrower preglabellar field, number of pygidial axial rings, and relatively long pygidial axis. This species is similar to *Ehmaniella* in its longer palpebral lobes and less tapering glabella. *Elrathiella? intermedia* is most similar to *E. domensa* but differs in its less tapered glabella, more tapered and more curved anterior border, weaker developed interpleural lobes, and more pygidial axial rings.

ETYMOLOGY. Latin, *intermedia* for its intermediate morphology between *Elrathiella* and *Ehmaniella*.

HOLOTYPE. Cranidium (LACMIP 11840) from the Pole Canyon Limestone, Member E, Schell Creek Range, Patterson Pass, Nevada (LACMIP locality 15574).

PARATYPES. LACMIP 11839 from LACMIP locality 15573; LACMIP 11841 from LACMIP locality 15574; LACMIP 11842, 11843 from LACMIP locality 15575.

OTHER MATERIAL. LACMIP locality 15573, 1 cranidium; LACMIP locality 15574, 1 cranidium; LACMIP locality 15575, 5 cranidia; LACMIP locality 15576, 1 cranidium; LACMIP locality 15577, 1 cranidium, 1 pygidium; LACMIP locality 15578, 4 cranidia.

OCCURRENCE. *Elrathiella* Subzone, *Ehmaniella* Biozone. Pole Canyon Limestone, Member E, Schell Creek Range, Patterson Pass, Nevada.

Elrathiella? cf. *E.?* *intermedia*,
new species

Figure 43

REMARKS. *Elrathiella?* cf. *E.?* *intermedia* is known from several distorted specimens from a single limestone sample. These specimens have convex, tapered anterior borders and slightly blunter frontal lobes, although the distortion of the specimens makes it difficult to determine whether these are primary taxonomic features or secondary tectonic features. The pygidium also shows the weak development of the anterior pleural bands and a transversely elongate, subelliptical shape that is typical of *E. intermedia*. The nomenclature of these specimens is left open because of their tectonic distortion.

HYPOTYPE. USNM 468965 from USGS locality 1982-CO.

OTHER MATERIAL. USGS locality 1982-CO, 7 cranidia, 1 pygidium.

OCCURRENCE. Middle *Ehmaniella* Biozone? Pole Canyon Limestone, Member E?, Snake Range, Nevada.

Elrathiella rectangularia,
new species

Figure 44

DIAGNOSIS. *Elrathiella* with cranidium with moderately elongate to elongated glabella (60–75% cranidial length), moderately tapered, moderately rounded frontal lobe; anterior border slightly convex, wide (65–75% frontal area length) evenly curved, slightly tapered; deep anterior border furrow; narrow fixigenae (30–40% glabellar width); non-granular ornamentation. Pygidium subrectangular, smooth; with anterior pleural bands absent or very weakly developed.

DESCRIPTION. Cranidium small, length 4.0–

5.0 mm; subrectangular, length 75–80% width; moderate convexity (sag. and trans.), height 35–40% width; anterior margin moderately curved, anterior margin width 75–80% cranidial width; posterior margin, excluding occipital ring, straight. Facial sutures moderately divergent from ends of palpebral lobes to anterior border furrow; moderately convergent across anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 60–75% and width 50–60% cranidial length; glabella width approximately 45% cranidial width; moderately tapered, width at anterior end 75–85% glabellar width; moderate convexity (sag. and trans.); anterior end moderately rounded, 3 lateral glabellar lobes. Axial furrows moderately deep, slightly deeper posteriorly, very slightly convex; preglabellar furrow moderately shallow, uniform depth, moderately curved; lateral glabellar furrows shallow, F1 furrow bifurcated, directed slightly posteriorly, F2 furrow directed slightly posteriorly, F3 furrow directed laterally. Occipital ring sagittal length 20–25% glabellar length, not elevated above glabella, moderately convex; small occipital node; furrow straight, moderate depth laterally, shallow medially; posterior margin curved. Frontal area length approximately 25% cranidial length, unequally divided. Preglabellar field very slightly convex, moderately downsloping, length 25–35% frontal area length. Anterior border slightly convex, level, uniform width medially, tapering laterally, evenly curved, sagittal length 65–75% frontal area length. Anterior border furrow evenly curved, deep, deeper than axial furrows. Fixigena width, exclusive of palpebral lobe, 30–40% glabellar width, moderately convexity, very slightly upsloping. Palpebral lobe narrow, width 15–20% lobe length; long, length 40–45% glabellar length; anterior margin located adjacent to 25–35% glabellar length from anterior margin of frontal lobe; furrow shallow. Ocular ridge moderately strong, directed strongly to moderately posterolaterally from glabella at 60–70° to axial trend. Posterior area of fixigena exsagittal width 25–35% glabellar length; length approximately 45% glabella length; sharply terminated? Posterior border high, strongly convex, slightly wider distally; border furrow narrow, deep, straight, wider laterally.

Librigena small, length 3.2 mm; moderately wide, width approximately 65% length without spine; height approximately 35% width; lateral margin moderately curved. Genal field gently convex, width approximately 45% librigenal width. Border width approximately 35% librigenal width; slightly convex; lateral border furrow shallow, shallowing posteriorly; posterior border furrow absent. Genal spine moderately short, approximately 45% length.

Hypostoma and thorax unknown.

Pygidium small, length 1.8–3.1 mm; subrectangular, length 60–75% width; margin smooth, anterior margin strongly curved posteriorly; lateral margins evenly curved; posterior margin flattened;

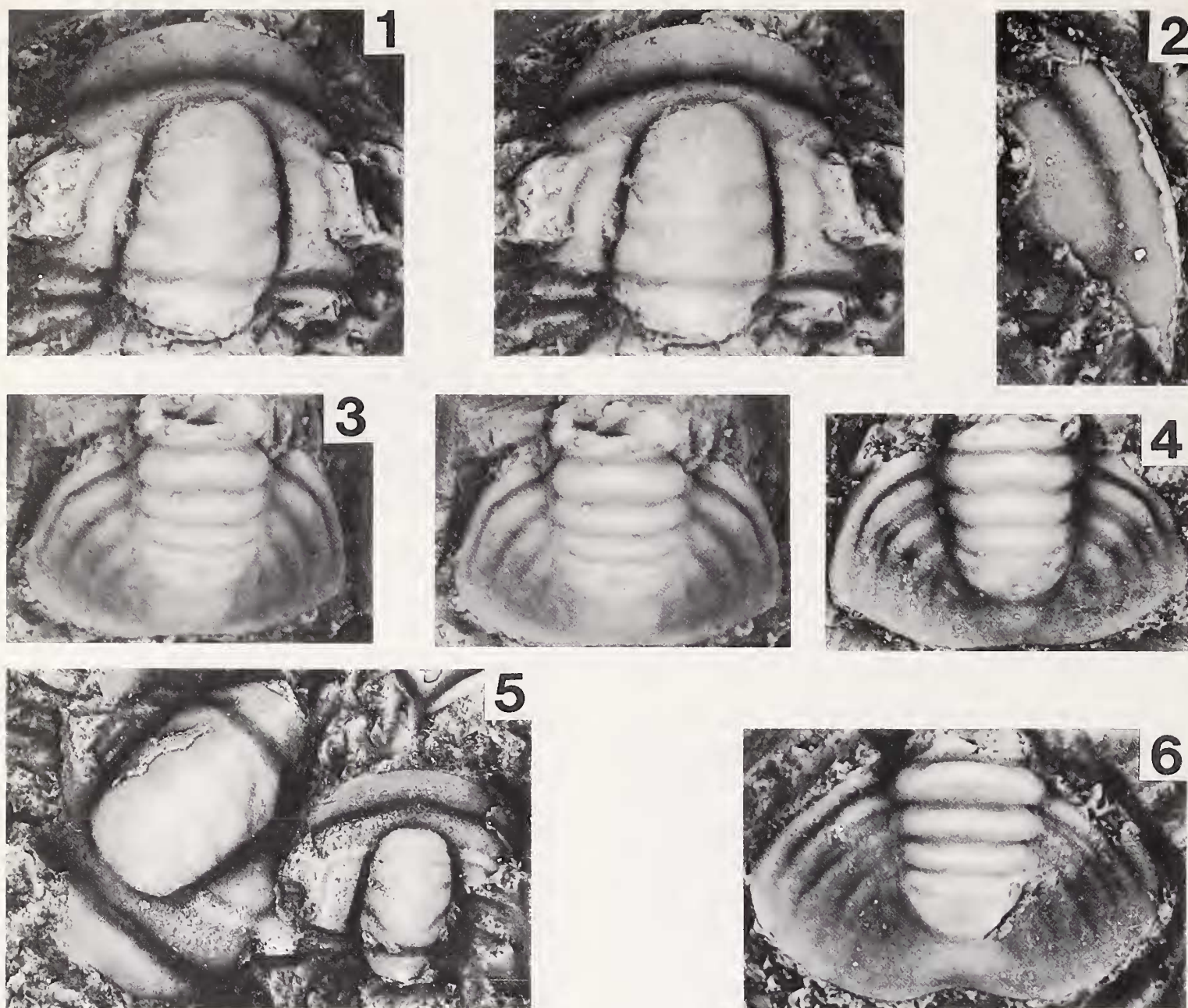


Figure 44. *Elrathiella rectangularia*, new species. 1, Stereo pair of holotype cranidium (LACMIP 11849), LACMIP locality 15592, exfoliated, $\times 9.1$. 2, Paratype free cheek (LACMIP 11844), LACMIP locality 15591, mostly exfoliated, $\times 10.2$. 3, Stereo pair of paratype pygidium (LACMIP 11852), LACMIP locality 15592, not exfoliated, $\times 11.9$. 4, Paratype pygidium (LACMIP 11851) show anterior pleural bands, LACMIP locality 15591, not exfoliated, $\times 11.0$. 5, Small (LACMIP 11845) and larger (LACMIP 11848) paratype cranidia, LACMIP locality 15591, mostly exfoliated, $\times 5.3$. 6, Larger paratype pygidium (LACMIP 11850) showing medial notch, LACMIP locality 15591, not exfoliated, $\times 9.0$.

moderate convexity (sag. and trans.), height 35–40% width. Axis slightly to moderately tapered, axial mid-width 80–90% axial anterior width, axial anterior width 40–45% pygidial width; axial length 60–80% pygidial length, no postaxial ridge; 4 axial rings, high convexity; terminal axial piece strongly rounded; axial furrow shallow; axial ring furrows moderate to shallow depth, deeper laterally. Pleural regions well defined, sagittally elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, moderately deep, extends to margin, curved strongly posterior; 3 additional pleural furrows, moderately shallow to shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows near margin; anterior pleural bands moderately convex; posterior pleural bands absent or very weakly developed. Border not defined.

Exoskeleton thin; genal caeca on prelabellar field,

anterior area of fixigena, and genal area of librigenae on external surfaces and internal mold; other parts smooth.

REMARKS. *Elrathiella rectangularia* is most similar to *E. dugwayensa* but differs in having narrower fixigenae, a wider anterior border, and non-granular ornamentation.

ETYMOLOGY. Latin, named for the subrectangular outline of the pygidium.

HOLOTYPE. Cranidium (LACMIP 11849) from the Eldorado Formation, northern Egan Range, Nevada (LACMIP locality 15592).

PARATYPES. LACMIP 11844, 11850–11852 from LACMIP locality 15592; LACMIP 11845–11848 from LACMIP locality 15591.

OTHER MATERIAL. LACMIP locality 15591, 1 cranidium, 1 pygidium; LACMIP locality 15592, 3 cranidia, 5 pygidia, 3 librigenae; LACMIP locality 15593, 3 cranidia, 1 pygidium, 2 librigenae.

OCCURRENCE. *Ehmaniella* Subzone, *Ehmaniella* Biozone. Eldorado Formation, northern Egan Range, Nevada.

Genus *Proehmaniella*, new genus

TYPE SPECIES. *Ehmaniella basilica* Resser, 1945.

DIAGNOSIS. Ehmaniellinae with subrectangular cranidium with divergent facial suture anterior of palpebral lobes; short to moderate length palpebral lobes (25–40% glabellar length); well-defined anterior border, narrow (5–10% cranidial length), slightly to very slightly tapered; preglabellar field sagittally wide (55–75% frontal area length); moderately to strongly tapered glabella, rounded frontal lobe; exsagittally wide posterior area of fixigenae (35–50% glabellar length). Pygidium alate with blunt axis, 2–3 axial rings; shallow depth pleural furrows; weakly to moderately convex posterior pleural bands; weak anterior pleural bands.

REMARKS. *Proehmaniella* is distinguished from *Elrathiella* in having a wider (sag.) preglabellar field, less rounded frontal lobe, generally smaller palpebral lobes, wider (exsag.) posterior area of fixigenae, alate pygidia, fewer axial rings, and weakly developed posterior and/or anterior pleural bands. *Proehmaniella* is distinguished from *Ehmaniella* in having a generally wider (sag.) preglabellar field, narrower anterior border, more rounded frontal lobe, smaller palpebral lobes, and wider (exsag.) posterior area of fixigenae.

Taxa assigned to *Proehmaniella* are *Ehmaniella basilica*; *Ehmaniella hebes* Resser, 1945; *Proehmaniella eldoradensa*, new species; and *P.?* *granulosa*. *Proehmaniella* is the earliest known ehmaniellid in the Great Basin. The genus occurs in the *Proehmaniella* Subzone in the lower portion of the *Ehmaniella* Biozone.

ETYMOLOGY. Latin, *pro-* = early, for early *Ehmaniella*.

Proehmaniella basilica (Resser, 1945)

Figure 45

Ehmaniella basilica Resser, 1945:206, pl. 20, figs. 19–20, pl. 23, figs. 10–13.

Pachyaspis moorei Resser, 1945:210–211, pl. 23, figs. 7–9.

“*Ehmaniella*” *basalica* Resser, Sundberg, 1991:388 fig. 2.20.

EMENDED DIAGNOSIS. *Proehmaniella* with cranidium with moderately rounded frontal lobe; frontal area moderately narrow (25–30% cranidial length); anterior border narrow (25–35% of frontal area), slightly curved, moderately convex; slightly posterolaterally directed ocular ridges (80–85° to axial trend); moderately wide fixigenae (50–60% glabellar width). Pygidium alate, blunt axis, anterior pleural bands very weak.



1



2



3

Figure 45. *Proehmaniella basilica* (Resser), exfoliated, LACMIP locality 15589. 1, Partially preserved articulated specimen (LACMIP hypotype 12003), $\times 5.3$. 2, Partially preserved articulated specimen (LACMIP hypotype 12001), $\times 3.8$. 3, Cranidium (LACMIP hypotype 12002), $\times 6.2$.

EMENDED DESCRIPTION. Cranidium small to moderate size, length 3.6–5.7 mm; subtrapezoidal, length 55–60% width; low(?) convexity (sag. and trans.); anterior margin slightly curved, anterior margin width 55–65% cranidial width; posterior margin, excluding occipital ring, slightly backswept.

Facial sutures slightly divergent from ends of palpebral lobes to anterior border furrow; strongly convergent across anterior border; divergent moderately strong posterior of palpebral lobes. Glabella moderately elongate, length 70–75% and width 50–55% cranial length; glabella width approximately 30% cranial width; moderately to strongly tapered, width at anterior end 65–80% glabellar width; low(?) convexity (sag. and trans.); frontal lobe bluntly to moderately rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, deeper posteriorly(?), straight; preglabellar furrow moderate depth, moderately curved; lateral glabellar furrows very shallow, F1 furrow bifurcated(?) directed posteriorly, F2 furrow directed laterally, F3 furrow directed slightly anteriorly, possible very shallow F4 furrow. Occipital ring sagittal length 15–20% glabellar length, moderately convex(?); small occipital node; furrow curved slightly anteriorly, moderate depth laterally, shallowing medially; posterior margin curved. Frontal area length 25–30% cranial length, unequally divided. Preglabellar field length 65–75% frontal area length. Anterior border convex, very slightly tapering laterally, evenly curved, sagittal length 25–35% frontal area length. Anterior border furrow evenly curved, moderately shallow, approximately equal depth to axial furrows. Fixigena width, exclusive of palpebral lobe, 50–60% glabellar width. Palpebral lobe narrow to moderate width, width 25–35% lobe length; short length, length 25–30% glabellar length; anterior margin located adjacent to 15–20% glabellar length from anterior margin of frontal lobe; furrow shallow. Ocular ridge moderate strength, directed slightly posterolaterally from glabella at 80–85° to axial trend. Posterior area of fixigena exsagittal width 40–50% glabellar length; length 75–90% glabella length; bluntly terminated. Posterior border strongly convex, uniform width; border furrow narrow, deep, straight, wider laterally.

Librigena small, length 3.1–3.6 mm; wide, width 40–45% length without spine; lateral margin moderately curved. Genal field width 55–60% librigenal width. Border width 10–15% librigenal width; gently convex; lateral border furrow shallow, deepening posteriorly; posterior border furrow moderately shallow. Genal spine short.

Hypostoma unknown.

Thirteen to 14 thoracic segments, moderate length, approximately 60% shield length. Pleura transversely moderately long, sagittally moderately wide, sharply terminated. Pleural furrow wide, moderate depth. Pleural lobes moderately convex. Axis narrow, approximately 65% pleural transverse length.

Pygidium small, length 1.2–1.7 mm; transversely elongate, length 40–45% width; margin smooth, anterior margin moderately curved posteriorly; lateral margins evenly curved; posterior margin slightly flattened; moderate(?) convexity (sag. and trans.). Axis slightly to moderately tapered, axial mid-width 70–90% axial anterior width, axial anterior width

35–40% pygidial width; axial length 85–90% pygidial length, no postaxial ridge; 3 axial rings, high convexity(?); terminal axial piece pointed; axial and axial ring furrows shallow depth, deeper laterally. Pleural regions well defined, transversely elongate, triangularly shaped; moderate convexity, down-sloping; anterior pleural furrow narrow, moderately shallow, extends to margin, curved strongly posterior; 2 additional pleural furrows, very shallow; interpleural furrows very shallow, joining with pleural furrows near margin; anterior pleural bands very weakly developed and slightly convex; posterior pleural bands moderately developed and slightly convex. Border narrow, width 10% pygidial length; very slightly convex, down-sloping; border furrow absent.

Exoskeleton small, length 9.7–15.7 mm; outline, suboval. Thickness unknown. Ornamentation generally unknown, genal caeca on librigena.

REMARKS. The emended diagnosis and descriptions are based on the figured specimens of Resser (1945) and the specimens collected for this study. Resser (1945) based *Ehmaniella basilica* on specimens preserved in shale and *Pachyaspis moorei* on specimens preserved in limestone. There are only minor differences in morphology between the figured specimens of the two species that cannot be explained by the differential compaction between shale and limestone specimens (particularly, see figs. 9 and 12, pl. 23, of Resser, 1945). *Pachyaspis moorei* generally has wider fixigenae, but this is a variable feature in both species. Because of the overall similarity of the two species, *Pachyaspis moorei* is synonymized with *Proehmaniella basilica*.

Proehmaniella basilica is most similar to *P. eldoradensis* but differs in having a less curved anterior border and wider preglabellar field. *Proehmaniella basilica* differs from *P. hebes* in having a narrower and less curved anterior border, shallower anterior border furrow, narrower preglabellar field, and narrower fixigena.

HYPOTYPES. LACMIP 12001–12003 from LACMIP locality 15589.

OTHER MATERIAL. LACMIP locality 15454, 9 cranidia; LACMIP locality 15456, 1 cranidium; LACMIP locality 15457, 2 cranidia; LACMIP locality 15458, 3 cranidia; LACMIP locality 15459, 9 cranidia; LACMIP locality 15460, 3 cranidia; LACMIP locality 15461, 6 cranidia; LACMIP locality 15501, 1 cranidium; LACMIP locality 15502, 31 cranidia, 2 librigenae; LACMIP locality 15584, 5 cranidia; LACMIP locality 15585, 10 cranidia; LACMIP locality 15586, 1 cranidium; LACMIP locality 15587, 1 cranidium, 1 librigena; LACMIP locality 15589, 17 cranidia, 2 pygidia, 3 librigenae; LACMIP locality 15608, 2 cranidia; LACMIP locality 15609, 1 cranidium; LACMIP locality 15610, 3 cranidia; LACMIP locality 15611, 3 cranidia; LACMIP locality 15612, 4 cranidia; LACMIP locality 15613, 5 cranidia.

OCCURRENCE. *Proehmaniella* Subzone, *Ehmaniella* Biozone. Bright Angle Shale, Grand Canyon, Arizona (Resser, 1945). Chisholm Formation,

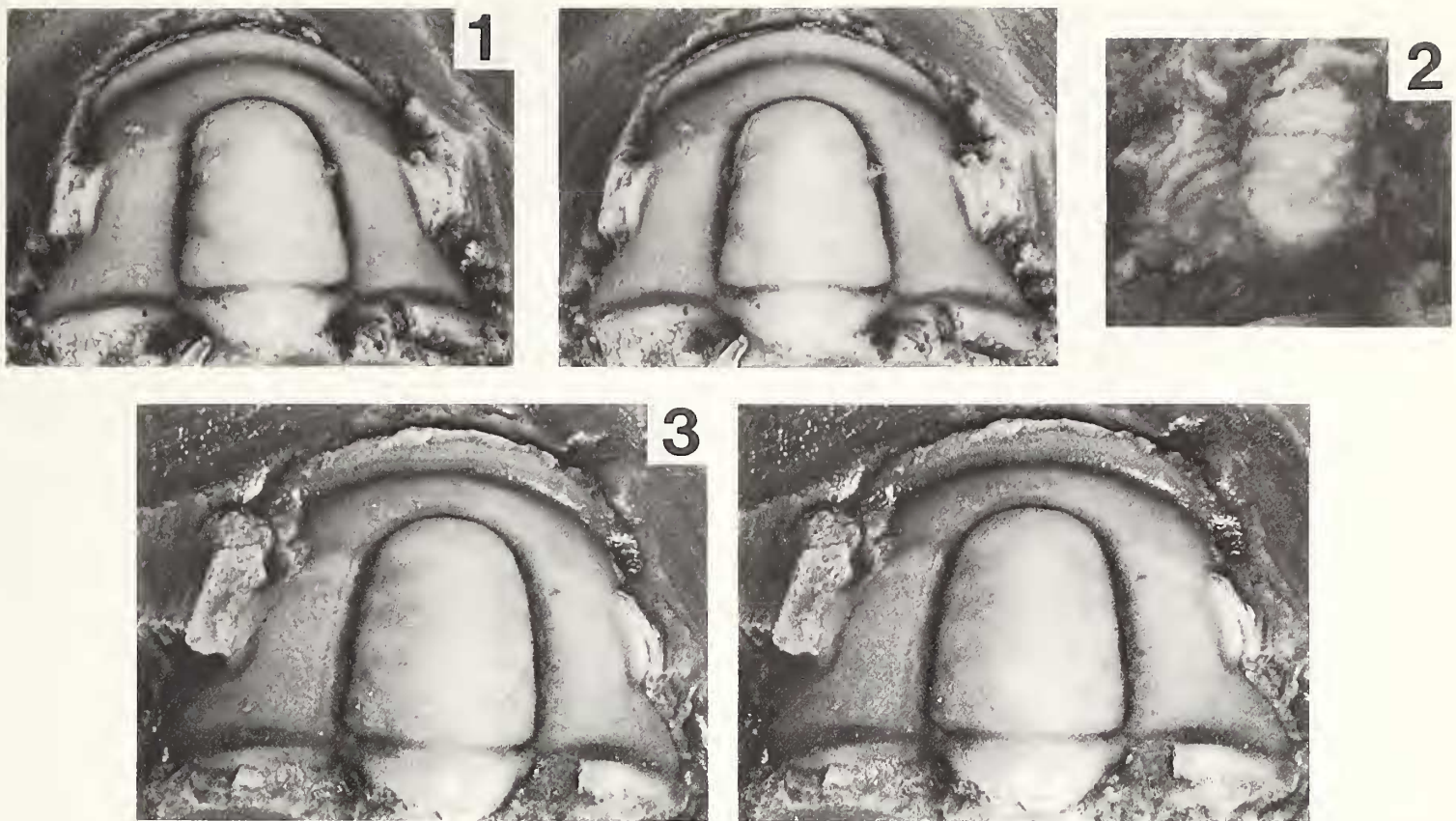


Figure 46. *Proehmaniella eldoradensa*, new genus and species, LACMIP locality 15583. 1, Stereo pair of holotype cranidium (LACMIP 11853), LACMIP locality 15583, exfoliated, $\times 7.1$. 2, Partial small paratype pygidium (LACMIP 11855), LACMIP locality 15583, not exfoliated, $\times 11.4$. 3, Stereo pair of paratype cranidium (LACMIP 11854), exfoliated, $\times 7.3$.

House Range and Drum Mountains, Utah. Eldorado Formation, northern Egan Range, Nevada.

***Proehmaniella eldoradensa*,
new species**

Figure 46

DIAGNOSIS. *Proehmaniella* with cranidium with anterior border moderately wide (40–45% frontal area length), moderately curved, strongly convex; moderately posterolaterally directed ocular ridges ($65\text{--}70^\circ$ to axial trend); very fine granular ornamentation. Pygidium alate, blunt axis, with 2 axial rings; anterior pleural bands moderately developed; scattered, relatively large granules.

DESCRIPTION. Cranidium small to moderate size, length 3.9–5.4 mm; trapezoidal, length 65–70% width; moderate convexity (sag. and trans.), height 30–40% cranidial width; anterior margin moderately curved, anterior margin width 60–75% cranidial width; posterior margin, excluding occipital ring, straight to slightly backswept. Facial sutures very slightly divergent from ends of palpebral lobes to approximately half way of the anterior border; strongly convergent across anterior border; moderately divergent posterior of palpebral lobes. Glabella moderately elongate, length 75–80% and width approximately 55% cranidial length; glabella width 35–45% cranidial width; strongly tapered, width at anterior end 70–75% glabellar width; moderate convexity (sag. and trans.); frontal lobe moderately rounded, 3 lateral glabellar lobes. Axial furrows moderately deep, deeper anteriorly, straight

to very slightly convex; prelabellar furrow moderately deep, moderately curved; lateral glabellar furrows very shallow, F1 furrow bifurcated, directed posteriorly, F2 furrow directed laterally, F3 furrow directed slightly anteriorly. Occipital ring sagittal length 20–25% glabellar length, elevated slightly above glabella, moderately convex; small occipital node; furrow straight, moderate depth laterally, shallowing medially; posterior margin curved. Frontal area length 20–25% cranidial length, subequally divided. Preglabellar field slightly convex, moderately downsloping, length 55–60% frontal area length. Anterior border convex, level to slightly downsloping, very slightly tapering laterally, evenly curved, sagittal length 40–45% frontal area length. Anterior border furrow evenly curved, moderate depth, moderately shallow medially, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 55–60% glabellar width, slightly convex, very slightly downsloping. Palpebral lobe narrow, width 25–30% lobe length; moderate length, length 30–35% glabellar length, upturned; anterior margin located adjacent to 20–30% glabellar length from anterior margin of frontal lobe; furrow moderately shallow, deeper posteriorly. Ocular ridge moderate to weak, directed moderately posterolaterally from glabella at $65\text{--}70^\circ$ to axial trend. Posterior area of fixigena exsagittal width 35–45% glabellar length; length approximately 55% glabella length; bluntly to sharply terminated. Posterior border moderately convex, uniform width; border furrow narrow, deep, straight, shallowing laterally.

Hypostoma, librigena, and thorax unknown.

Pygidium small, length 1.1 mm; suboval, length approximately 60% width; margin smooth, anterior margin moderately curved posteriorly; lateral margins evenly curved; posterior margin slightly flattened; moderately low convexity (sag. and trans.), height 35% width. Axis moderately tapered, axial mid-width approximately 75% axial anterior width, axial anterior width approximately 45% pygidial width; axial length approximately 80% pygidial length, no postaxial ridge; 2 axial rings, high convexity; terminal axial piece bluntly rounded; axial and axial ring furrows shallow. Pleural regions well defined, transversely elongate, triangularly shaped; low convexity, downsloping; anterior pleural furrow narrow, moderately deep, extends to margin, curved strongly posterior; an additional pleural furrows, moderate depth; interpleural furrows moderate depth to shallow, joining with pleural furrows near margin. Border narrow, width 10% pygidial length; very slightly convex, level; border furrow absent.

Exoskeleton thin; fine granules on all parts of cranidia, scattered coarse granules on pygidia on external surfaces; internal surfaces smooth.

REMARKS. *Proehmaniella eldoradensa* is known from several cranidia and only one fragmented, small pygidium. This species is most similar to *P. basilica* but differs in having a more curved and a narrower (trans.) width of the anterior border and narrower (sag.) frontal area.

ETYMOLOGY. Latinized, named after the Eldorado Formation.

HOLOTYPE. Cranidium (LACMIP 11853) from the Eldorado Formation, northern Egan Range, Nevada (LACMIP locality 15583).

PARATYPES. LACMIP 11854–11857 from LACMIP locality 15583.

OTHER MATERIAL. LACMIP locality 15583, 16 cranidia.

OCCURRENCE. *Proehmaniella* Subzone, *Ehmaniella* Biozone. Eldorado Formation, northern Egan Range, Nevada.

Proehmaniella? granulosa,
new species

Figure 47

DIAGNOSIS. *Proehmaniella?* with cranidium with blunt to moderately rounded frontal lobe; frontal area moderately narrow (25–35% cranial length); anterior border moderately wide (35–50% frontal area length), moderately curved, slightly convex to flat; moderately posterolateral directed ocular ridges (65–70° from axial trend); wide fixigenae (60–65% glabellar width); moderately fine granular ornamentation. Pygidium subcircular, elongated axis, anterior pleural bands moderately well developed; smooth exoskeleton.

DESCRIPTION. Cranidium small to moderate size, length 3.3–7.8 mm; rectangular, length 60–

65% width; moderate convexity (sag. and trans.), height 25–30% width; anterior margin moderately curved, anterior margin width 70–75% cranial width; posterior margin, excluding occipital ring, moderately backswept. Facial sutures slightly to moderately divergent from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of anterior border; strongly divergent posterior of palpebral lobes. Glabella moderately elongate, length 65–75% and width 45–50% cranial length; glabella width 30–35% cranial width; strongly tapered, width at anterior end 65–75% glabellar width; high convexity (sag. and trans.); frontal lobe bluntly to moderately rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, deeper posteriorly, slightly concave; preglabellar furrow moderate depth, moderately curved; lateral glabellar furrows shallow, F1 furrow bifurcated, directed posteriorly, F2 and F3 furrows directed slightly anteriorly, possible very shallow F4 furrow. Occipital ring sagittal length 20–25% glabellar length, slightly elevated above glabella, moderately convex; small occipital node; furrow curved anteriorly, deeper laterally, moderate depth; posterior margin curved. Frontal area length 25–35% cranial length, subequally divided. Preglabellar field slightly convex, moderately downsloping, length 50–65% frontal area length. Anterior border flat to slightly convex, upsloping, tapering slightly laterally, evenly curved, sagittal length 35–50% frontal area length. Anterior border furrow evenly curved, shallow, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 60–65% glabellar width, low convexity, slightly upsloping. Palpebral lobe narrow, width 25–30% lobe length; moderate length, length 30–40% glabellar length; anterior margin located adjacent to 20–30% glabellar length from anterior margin of frontal lobe; furrow shallow. Ocular ridge moderate strength, directed moderately posterolaterally from glabella at 65–70° to axial trend. Posterior area of fixigena exsagittal width 35–40% glabellar length; length 65–80% glabella length; sharply terminated. Posterior border strongly convex, uniform width; border furrow narrow, deep, straight, wider laterally.

Hypostoma, librigena, and thorax unknown.

Pygidium small, length 3.2 mm; subcircular, length approximately 55% width; margin smooth, anterior margin moderately curved posteriorly; lateral margins moderately curved; posterior margin moderately curved; moderate convexity (sag. and trans.), height approximately 35% width. Axis moderately tapered, axial mid-width approximately 80% axial anterior width, axial anterior width approximately 45% pygidial width; axial length approximately 75% pygidial length; low relief postaxial ridge reaching border; 5 axial rings, high convexity; terminal axial piece sharply rounded; axial furrows moderate depth, shallower posteriorly; axial ring furrows moderate depth to shallow, deeper laterally. Pleural regions well defined, transversely elongate, triangularly shaped; moderate convexity, downsloping;

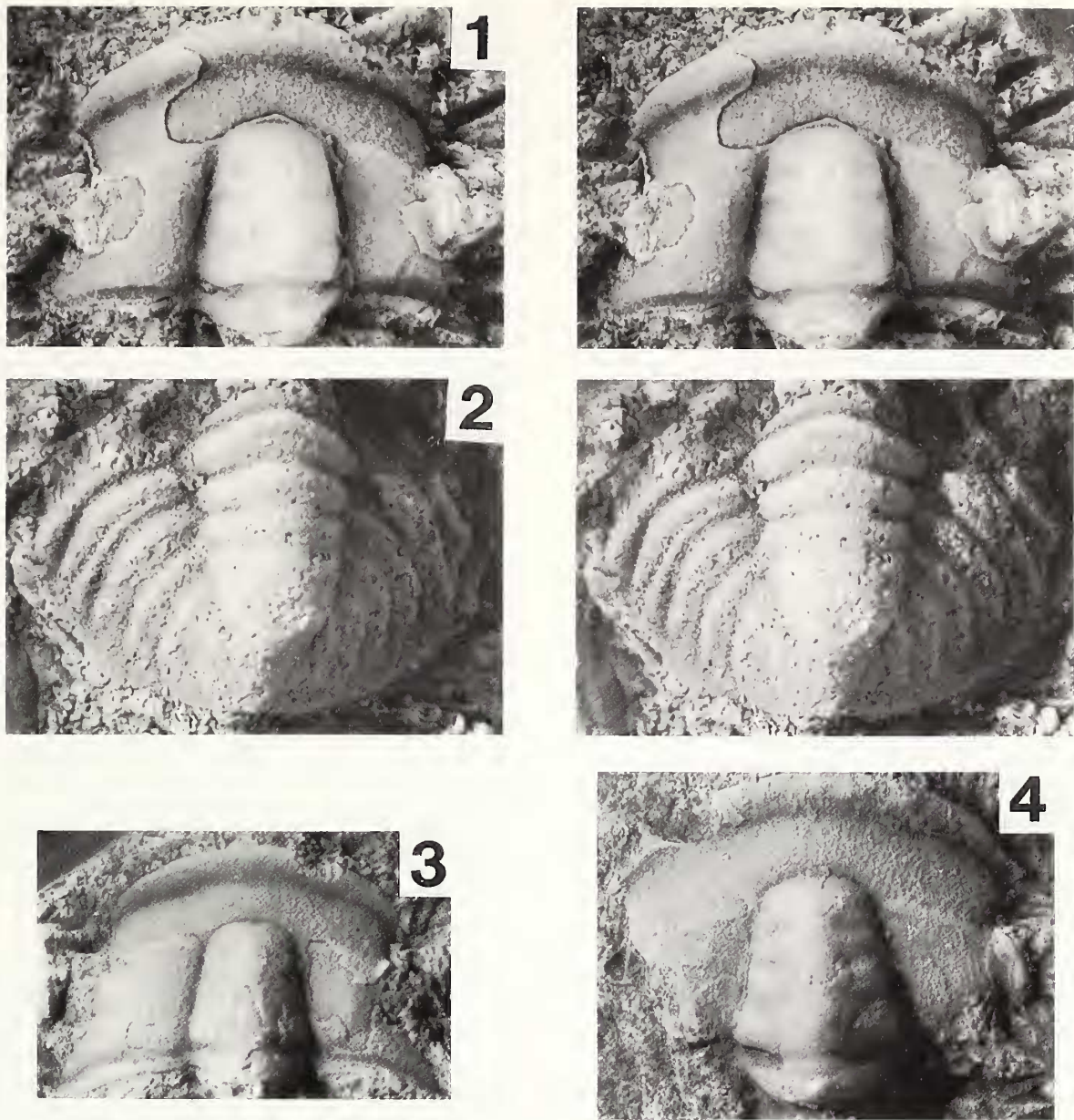


Figure 47. *Proehmaniella? granulosa*, new genus and species, RC locality 375. 1, Stereo pair of holotype cranidium (KUMIP 204746), partially exfoliated, $\times 7.9$. 2, Stereo pair of paratype pygidium (KUMIP 204750), exfoliated, $\times 9.1$. 3, Paratype cranidium (KUMIP 204747), partially exfoliated, $\times 5.9$. 4, Larger paratype cranidium (KUMIP 204748), exfoliated, $\times 4.1$.

anterior pleural furrow narrow, moderately deep, extends to margin, curved strongly posterior; 4 additional pleural furrows, moderate depth to shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows near margin; anterior pleural bands narrow, moderately well developed; posterior pleural bands well developed, moderately convex. Border narrow, width approximately 10% pygidial length; very slightly convex, downsloping; border furrow absent.

Exoskeleton thin; abundant, very fine granules on external surface of glabella; pygidia smooth on internal surface.

REMARKS. *Proehmaniella? granulosa* is intermediate in morphology between *Proehmaniella* and *Elrathiella*. If the single pygidium is correctly assigned to the species, then, with its subcircular outline, elongated axis, and well-defined anterior pleural bands, the pygidium is more typical of *Elrathiella* than *Proehmaniella*. *Proehmaniella? granulosa* also has a more rounded frontal lobe, similar to *Elrathiella*. However, the other cranidial features are similar to other species of *Proehmaniella*. Because

of the mixture of cranidial and pygidial features, the species is questionably assigned to *Proehmaniella*.

Proehmaniella? granulosa is most similar to *P. basilica* but differs in having an anterior border that is wider (sag.) and stronger curved and wider fixigenae.

ETYMOLOGY. Latin, named for its granular ornamentation.

HOLOTYPE. Cranidium (KUMIP 204746) from the Dome Limestone, House Range, Utah (RC locality 375).

PARATYPES. KUMIP 204747–204750 from RC locality 375.

OTHER MATERIAL. RC locality 375, 16 cranidia.

OCCURRENCE. *Proehmaniella* Subzone, *Ehmaniella* Biozone. Dome Limestone, House Range, Utah.

Proehmaniella hebes?
(Resser, 1945)
Figure 48

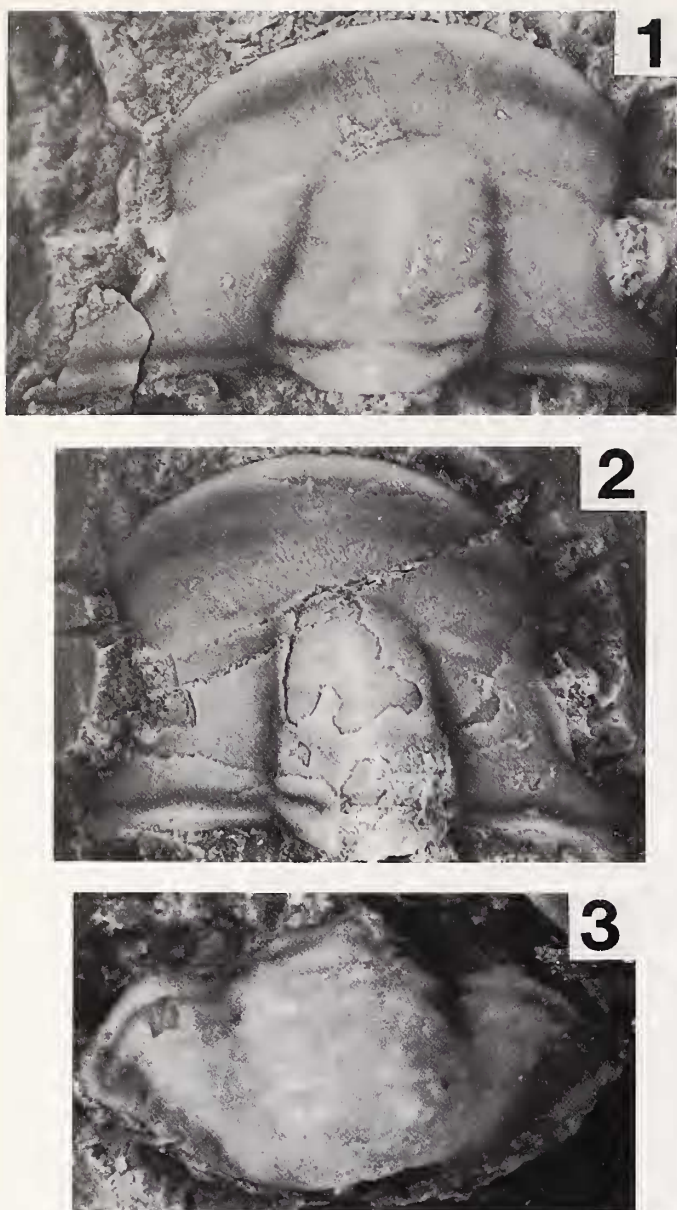


Figure 48. *Proehmaniella hebes*? (Resser), specimens distorted. 1, Cranidium (LACMIP hypotype 12005), LACMIP locality 15553, exfoliated, $\times 6.0$. 2, Cranidium (LACMIP hypotype 12006), LACMIP locality 15553, partially exfoliated, $\times 5.1$. 3, Pygidium (LACMIP hypotype 12004), LACMIP locality 15550, not exfoliated, $\times 7.5$.

Ehmaniella hebes Resser, 1945:206–207, pl. 24, figs. 2–6.

REMARKS. Several specimens of *Proehmaniella* are found in the upper portion of Member C of the Pole Canyon Limestone, Snake Range. All of the specimens are distorted, thus preventing accurate species assignment and description. These specimens resemble *P. hebes* in their shallow anterior border furrow, moderate depth of the axial furrows, and relatively wide, tapering anterior border. *Proehmaniella hebes*? differs from type specimens from the Grand Canyon in its sagittally shorter length of the preglabellar field and more tapered anterior border.

HYPOTYPES. LACMIP 12004 from LACMIP locality 15550; LACMIP 12005, 12006 from LACMIP locality 15553.

OTHER MATERIAL. LACMIP locality 15549, 8 cranidia; LACMIP locality 15550, 15 cranidia; LACMIP locality 15551, 57 cranidia, 1 librigena; LACMIP locality

15552, 10 cranidia, 1 pygidium; LACMIP locality 15553, 18 cranidia, 1 pygidium.

OCCURRENCE. *Proehmaniella* Subzone, *Ehmaniella* Biozone. Pole Canyon Limestone, Member C, Snake Range.

Genus *Pseudomexicella*, new genus

TYPE SPECIES. *Pseudomexicella hestia*, new species.

DIAGNOSIS. Ehmaniellinae with subpentagonal cranidium with divergent facial sutures anterior of palpebral lobes; moderately to long palpebral lobes (35–40% glabellar length); poorly defined anterior border, gently and uniformly convex preglabellar field and anterior border, shallow anterior border furrow, moderate width (15–20% cranidial length), very strongly tapered; preglabellar field sagittally moderately wide (40–60% frontal area length); moderately to strongly tapered glabella; bluntly rounded frontal lobe; exsagittally wide posterior area of fixigenae (25–30% glabellar length). Pygidium subelliptical with elongate axis; 4 axial rings; moderate depth pleural furrows; strongly convex posterior pleural bands; without anterior pleural bands.

REMARKS. *Pseudomexicella* differs from *Ehmaniella* in its downsloping convex preglabellar field and anterior border, very shallow anterior border furrow, and pointed terminations of the posterior area of fixigenae. Glabellar features of *Pseudomexicella* are very similar to *Proehmaniella* in its number of lobes, concave axial furrow, and bluntly rounded frontal lobe. These characters place *Pseudomexicella* in the Ehmaniellinae.

Pseudomexicella superficially resembles the genus *Mexicella* Lochman, 1948, from the older *Albertella* Biozone (Lochman, 1948; Lochman in Cooper et al., 1952; Palmer and Halley, 1979) in the construction of its frontal area. *Mexicella* differs from *Pseudomexicella* in having convex glabellar axial furrows, lacking a glabellar medial ridge, anterior end of the glabella being 60–70% of glabella width (*P. hestia*, new species, has a ratio of 80–90%), rounded posterior area of fixigenae, straight or converging sutures anterior of palpebral lobes, smaller palpebral lobes, shallower palpebral furrows, and ocular ridges directed 80–85° to the axial trend (*P. hestia* has 60–65°). Specimens of *Mexicella stator* (Walcott, 1916) illustrated by Rasetti (1951: pl. 20, figs. 14–19) have glabellar features typical of kochaspids (Palmer and Halley, 1979) and may not belong to the genus *Mexicella*.

ETYMOLOGY. Greek, *pseudo* = false, for the superficial similarity of the genus to *Mexicella*.

Pseudomexicella hestia, new species

Figure 49

DIAGNOSIS. Same as genus.

DESCRIPTION. Cranidium moderate size, length

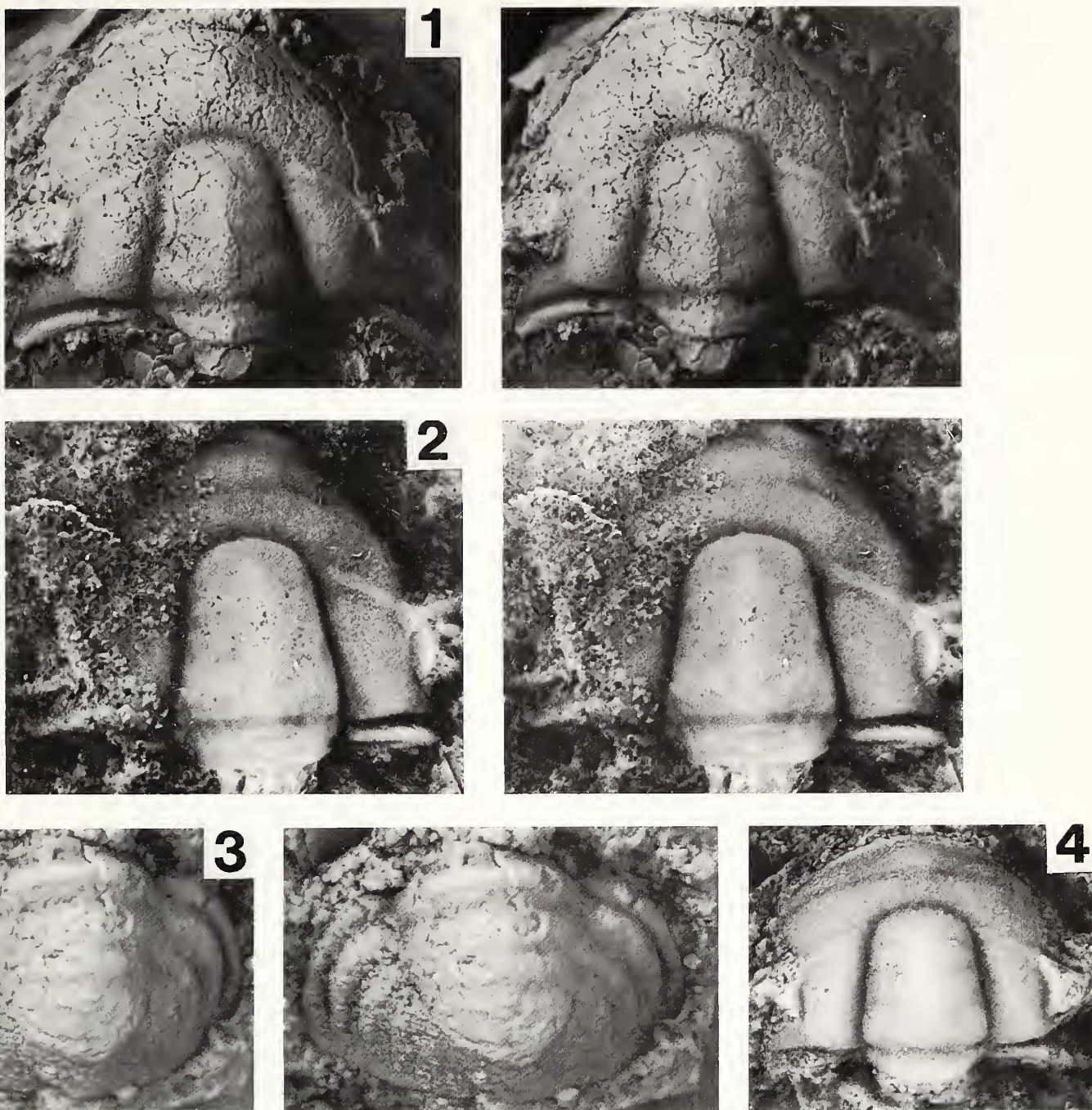


Figure 49. *Pseudomexicella hestia*, new genus and species. 1, Stereo pair of holotype cranium (KUMIP 204753), RC locality 211, exfoliated, $\times 4.6$. 2, Stereo pair of latex cast of partial paratype cranium (KUMIP 204755), RC locality 374, not exfoliated, $\times 4.5$. 3, Stereo pair of paratype pygidium (KUMIP 204752), RC locality 211, slightly exfoliated, $\times 11.3$. 4, Small paratype cranium (KUMIP 204754), RC locality 374, not exfoliated, $\times 9.4$.

3.0–8.3 mm; subpentagonal, length 70–75% width; moderate convexity (sag. and trans.), height 30–45% width; anterior margin strongly curved, anterior margin width 70–80% cranial width; posterior margin, excluding occipital ring, backswept moderately strong. Facial sutures moderately divergent from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 65–75% and width 50–55% cranial length; glabella width 35–40% cranial width; strongly tapered, width at anterior end 65–75% glabellar width; low convexity (sag. and trans.), medial ridge; frontal lobe bluntly rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, deeper posteriorly, slightly concave; preglabellar furrow moderate depth, moderately curved; lateral glabellar furrows very shallow to effaced, F1 furrow bifurcated, di-

rected posteriorly, F2 and F3 furrows directed slightly anteriorly. Occipital ring sagittal length 20–25% glabellar length, slightly elevated above glabella, moderately convex; small occipital node; furrow straight, deeper lateral shallowing medial, moderate to shallow depth; posterior margin curved. Frontal area length 25–30% cranial length, equally to subequally divided. Preglabellar field slightly convex, slightly downsloping, length 40–60% frontal area length. Anterior border slightly convex, moderately downsloping, strongly tapering laterally, evenly curved, sagittal length 40–60% frontal area length. Anterior border furrow evenly curved, very shallow, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 45–50% glabellar width, low convexity, level. Palpebral lobe narrow, width 20–25% lobe length; moderate length, length 35–40% glabellar length; anterior margin located adjacent to 25–35% glabellar length

from anterior margin of frontal lobe; furrow shallow. Ocular ridge low relief, directed strongly posterolaterally from glabella at 60–65° to axial trend. Posterior area of fixigena exsagittal width 25–30% glabellar length; length 60–70% glabella length; very sharply terminated. Posterior border strongly convex, uniform thickness; border furrow moderately wide, deep, curved posterolaterally, wider laterally.

Librigena, hypostoma, and thorax: unknown.

Pygidium small, length 2.3 mm; subelliptical, transversely elongate, length 55–60% width; margin smooth, anterior margin strongly curved posteriorly; lateral margins and posterior margin evenly curved; moderate convexity (sag. and trans.), height approximately 50% of pygidial width. Axis moderately tapered, axial mid-width approximately 80% axial anterior width, axial anterior width approximately 50% pygidial width; axial length approximately 85% pygidial length; no postaxial ridge; 4 axial rings, high convexity; terminal axial piece rounded; axial and axial ring furrows shallow depth, deeper laterally. Pleural regions well defined, sagittally elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, moderately shallow, extends to margin, curved strongly posterior; 3 additional pleural furrows, very shallow; interpleural furrows very shallow, joining with pleural furrows near margin; anterior pleural bands not developed; posterior pleural bands moderately developed, moderately convex. Border narrow, width approximately 5% pygidial length; very slightly convex, downsloping; border furrow absent.

Exoskeleton thin; external surface and internal mold smooth.

REMARKS. *Pseudomexicella hestia* is the only known species of the genus.

ETYMOLOGY. Greek, *hestia* = house, named after the House Range.

HOLOTYPE. Cranidium (KUMIP 204753) from the Dome Limestone, House Range, Utah (RC locality 211).

PARATYPES. KUMIP 204752 from RC locality 211; KUMIP 204754, 204755 from RC locality 374.

OTHER MATERIAL. RC locality 211, 3 cranidia; RC locality 374, 3 cranidia.

OCCURRENCE. *Proehmaniella* Subzone, *Ehmaniella* Biozone. Dome Limestone, House Range, Utah.

Genus *Trachycheilus* Resser, 1945

TYPE SPECIES. *Trachycheilus typicalus* Resser, 1945.

EMENDED DIAGNOSIS. Ehmaniellinae with subpentagonal to trapezoidal cranidium with convergent facial sutures anterior of palpebral lobes; short to moderate palpebral lobes (20–35% glabellar length); well-defined anterior border, narrow to moderate width (5–20% cranidial length), moderate to strongly tapered; preglabellar field sagittally

narrow to moderately wide (15–45% frontal area length); strongly to very strongly tapered glabella; moderately to bluntly rounded frontal lobe; exsagittally wide posterior area of fixigenae (35–55% glabellar length). Pygidium subcircular to subelliptical with elongate axis; 5 axial rings; moderate depth pleural furrows; moderate to strong posterior pleural bands; weak to absent anterior pleural bands.

REMARKS. *Trachycheilus* was named by Resser (1945:212) for a single cranidium from either the Bright Angel Shale or Muav Limestone of the Grand Canyon, Arizona. He characterized the cranidium as plump and having a “rugged” anterior border and an unusually tapering glabella with a rounded frontal lobe. *Trachycheilus* is characterized by having a subpentagonal cranidium with an inflated, strongly tapered glabella that is well elevated above the fixigena, exsagittally wide posterior area of fixigenae; and well-developed anterior border and anterior border furrow. *Trachycheilus* differs from *Solenopleurella* Poulsen, 1927, and *Spencella* by having a subpentagonal to trapezoidal cranidium, conical glabella, and pygidium with well-developed anterior and posterior pleural bands and pleural and interpleural furrows that join at the border. The pygidium of *Trachycheilus* is very similar to that of *Elrathiella*, suggesting that the genus belongs in Ehmaniellinae.

Trachycheilus occurs in the middle and upper *Ehmaniella* Biozone.

Trachycheilus granulosus, new species

Figure 50

DIAGNOSIS. *Trachycheilus* with moderate size, subpentagonal cranidium with narrow to moderate width anterior border (55–70% frontal area), no median inbend; glabella with deep axial and lateral glabellar furrows, strongly convex, rounded frontal lobe; scattered coarse granular ornamentation; no nodes on posterior border. Pygidium subtriangular with weakly convex or absent anterior pleural bands, strongly developed posterior pleural bands, moderately dense medium size granules.

DESCRIPTION. Cranidium moderate size, length 6.0–7.9 mm; subpentagonal, length 60–80% width; moderate convexity (sag. and trans.), height 25–40% width; anterior margin moderately, evenly curved, anterior margin width 65–80% cranidial width; posterior margin, excluding occipital ring, straight to very slightly backswept. Facial sutures moderately convergent from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of anterior border; moderately divergent posterior of palpebral lobes. Glabella elongate, length 75–90% and width 55–65% cranidial length; glabella width 35–45% cranidial width; strongly tapered, width at anterior end 65–75% glabellar width; high convexity (sag. and trans.); frontal lobe moderately rounded, 4 lateral glabellar lobes.

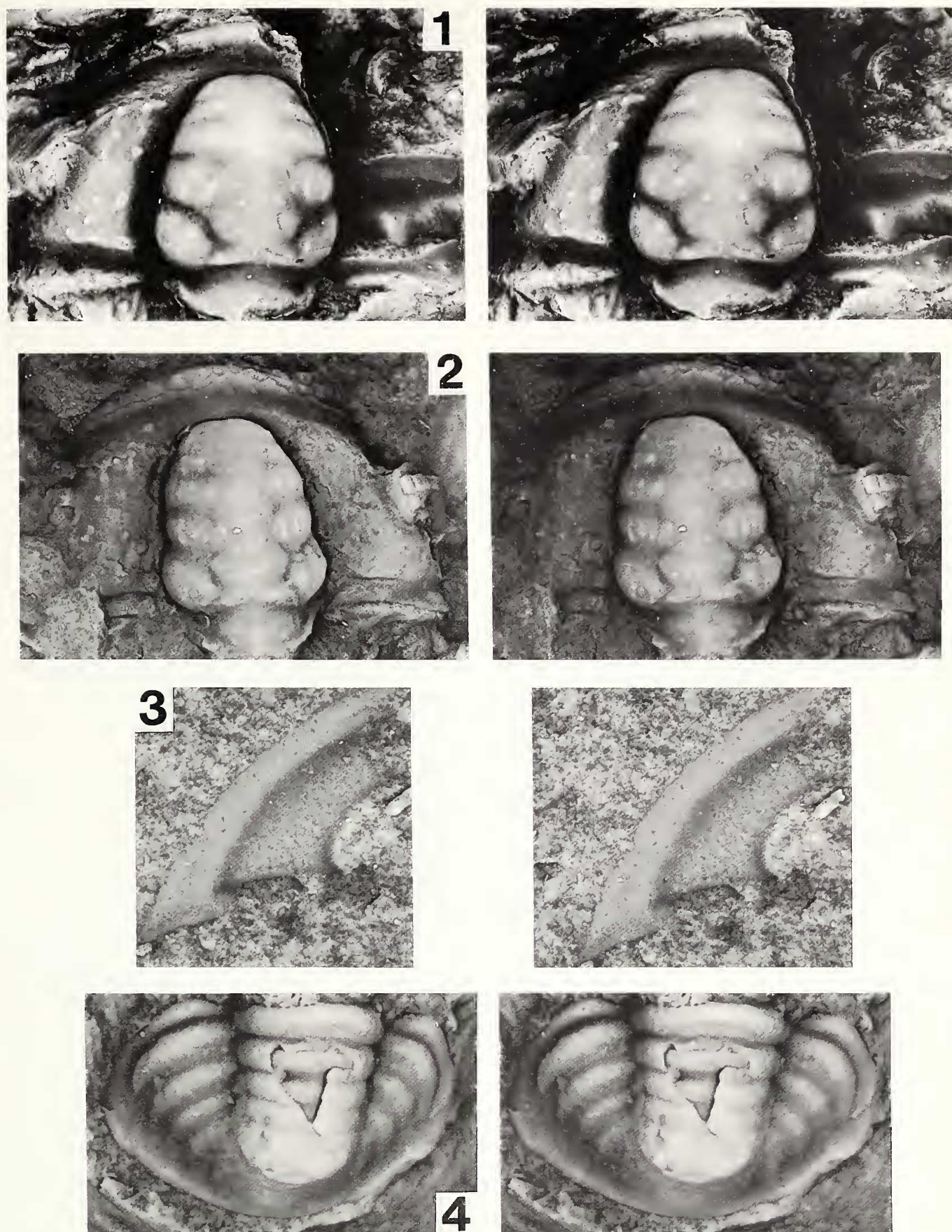


Figure 50. *Tachycheilus granulatus*, new species. 1, Stereo pair of paratype cranidium (LACMIP 11859), LACMIP locality 15465, exfoliated, $\times 5.3$. 2, Stereo pair of latex cast of holotype cranidium (LACMIP 11858), LACMIP locality 15465, partially exfoliated, $\times 5.4$. 3, Stereo pair of paratype free cheek (LACMIP 11865), LACMIP locality 15520, exfoliated, $\times 9.7$. 4, Stereo pair of paratype pygidium (LACMIP 11864), LACMIP locality 15520, slightly exfoliated, $\times 9.0$.

Axial furrows very deep, uniform depth, moderately to slightly convex; preglabellar furrow moderately deep, joining with anterior border furrow, narrow, moderately curved; lateral glabellar furrows moderately shallow to moderately deep, F1 furrow deep, bifurcated, directed posteriorly, F2 and F3 furrows moderate depth, directed laterally, F4 furrow shallow to absent, directed slightly an-

teriorly. Occipital ring sagittal length 15–25% glabellar length, not elevated above glabella, low convexity; no occipital node?; furrow curved anteriorly, deep; posterior margin moderately curved. Frontal area length 10–25% cranidial length, unequally divided. Preglabellar field moderately downsloping, length 30–45% frontal area length. Anterior border strongly convex, moderately tapering laterally,

evenly curved, no median inbend, sagittal length 55–70% frontal area length. Anterior border furrow evenly curved, moderately wide, deep, as deep as or slightly shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 40–55% glabellar width, moderate convexity, slightly downsloping, anterior area strongly downsloping. Palpebral lobe narrow, width 25–30% lobe length; short, length, 20–30% glabellar length; anterior margin located adjacent to 20–30% glabellar length from anterior margin of frontal lobe, level to slightly upsloping, furrow shallow. Ocular ridge weak to absent, thin, directed moderately posterolaterally from glabella at 65–75° to axial trend. Posterior area of fixigena exsagittal width 35–55% glabellar length; length 50–60% glabella length; downsloping, roundly terminated. Posterior border high, strongly convex, uniform width, nodes absent; border furrow wide, deep, straight, wider laterally.

Librigena small, length 3.7–4.2 mm; moderately wide, width 40–45% length without spine; lateral margin gently curved; moderate convexity, height 30–40% width. Genal field gently convex, width 50–60% librigenal width. Border width 25–35% librigenal width; gently convex; lateral border furrow wide, shallow, shallowing posteriorly; posterior border furrow shallow, shallowing laterally. Genal spine short, 15–22% librigenal length.

Hypostoma and thorax unknown.

Pygidium small, length 2.8 mm; subcircular, length approximately 60% width; margin smooth, anterior margin straight, laterally curved posteriorly; lateral and posterior margins evenly curved; moderate convexity (sag. and trans.), height approximately 50% width. Axis very slightly tapered, axial mid-width approximately 95% axial anterior width, axial anterior width approximately 40% pygidial width; axial length approximately 90% pygidial length, no postaxial ridge; 5 axial rings, high convexity; terminal axial piece rounded; axial and axial ring furrows deep to very shallow, deeper laterally. Pleural regions well defined, sagittally elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, deep, extends to border, strongly curved posteriorly; 4 additional pleural furrows, shallow to very shallow; interpleural furrows shallow to very shallow, joining with pleural furrows at border; anterior pleural bands weakly convex or absent; posterior pleural bands strongly to moderately convex. Border narrow, width approximately 5% pygidial length; wider laterally, slightly convex, upturned laterally; border furrow absent.

Exoskeleton thin; scattered coarse granules on cranidium external surface and internal mold; moderately dense, moderate size granules on genal areas of librigena internal surface and pygidia external surface.

REMARKS. *Trachycheilus granulatus* shows variation in the inflation of the preoccipital lobe of the glabella, convexity of the axial furrows, and curvature of the anterior border. These variations

occur within one stratigraphic collection and represent morphologic differences within a population.

Trachycheilus granulatus differs from *T. typicalus* and *T. whirlwindensis* in its coarse granular ornamentation, strongly convex glabella, and relatively deep axial and lateral glabellar furrows.

ETYMOLOGY. Latin, for its coarse granules on the cranidium.

HOLOTYPE. Cranidium (LACMIP 11858) from the Whirlwind Formation, Drum Mountains, Utah (LACMIP locality 15465).

PARATYPES. LACMIP 11859 from LACMIP locality 15465; LACMIP 11860–11863 from LACMIP locality 15466; LACMIP 11864, 11865 from locality 15520.

OTHER MATERIAL. LACMIP locality 15465, 3 cranidia; LACMIP locality 15466, 2 cranidia; LACMIP locality 15508, 2 cranidia, 2 librigenae; LACMIP locality 15520, 5 cranidia, 2 pygidia, 3 librigenae.

OCCURRENCE. *Elrathiella* Subzone, *Ehmaniella* Biozone. Whirlwind Formation, Drum Mountains and House Range, Utah. Shadscale Formation, Dugway Range, Utah.

Trachycheilus whirlwindensis, new species

Figures 51, 52

Trachycheilus, n. sp. Sundberg, 1991:388, fig. 2.16.

DIAGNOSIS. *Trachycheilus* with small subpentagonal cranidium with sagittally narrow to wide (65–85% frontal area) and transversely wide (55–75% cranial width) anterior border, no or very slight median inbend; glabella with moderate depth axial and lateral glabellar furrows, slightly flattened to flattened frontal lobe; smooth exoskeleton, nodes present or absent on posterior border. Pygidium subelliptical with moderately to weakly convex anterior and posterior bands, smooth surface.

DESCRIPTION. Cranidium small, length 3.1–5.2 mm; subpentagonal, length 60–80% width; moderate convexity (sag. and trans.), height 30–40% width; anterior margin moderately, evenly curved, anterior margin width 55–75% cranial width; posterior margin, excluding occipital ring, slightly to moderately backswept. Facial sutures convergent from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of anterior border; moderately divergent posterior of palpebral lobes. Glabella elongate, length 75–85% and width 55–65% cranial length; glabella width 40–50% cranial width; very strongly to strongly tapered, width at anterior end 60–75% glabellar width; moderately high convexity (sag. and trans.); frontal lobe moderately rounded to slightly flattened, 4 lateral glabellar lobes. Axial furrows moderately deep to deep, uniform depth, moderately to slightly convex; preglabellar furrow moderately deep, joining with anterior border furrow, narrow, moderately curved; lateral glabellar furrows moderately shallow to moderate depth, F1

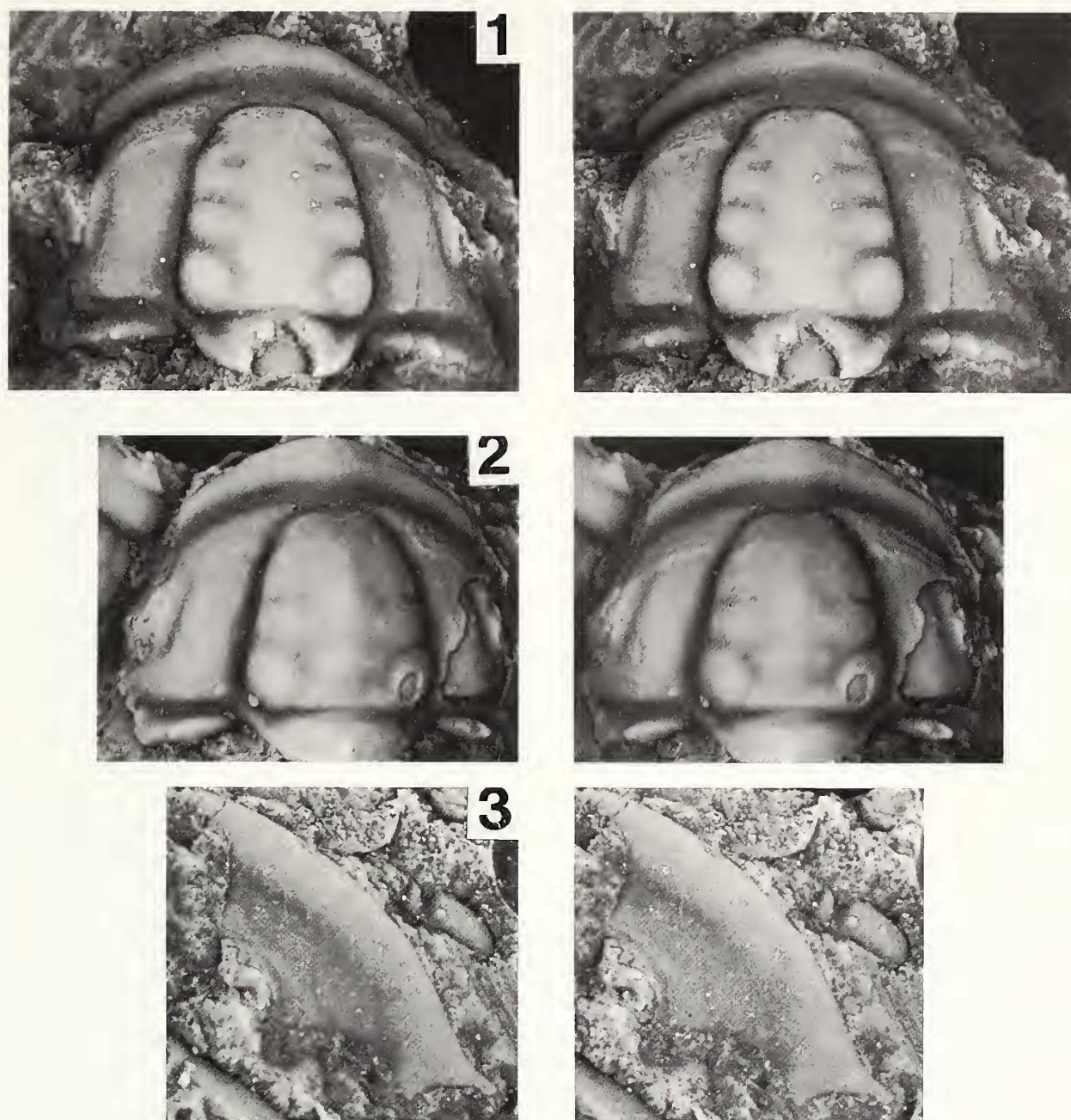


Figure 51. *Tachycheilus whirlwindensis whirlwindensis*, new species and subspecies, LACMIP locality 15468. 1, Stereo pair of paratype cranidium (LACMIP 11880), exfoliated, $\times 10.8$. 2, Stereo pair of holotype cranidium (LACMIP 11876), partially exfoliated, $\times 7.4$. 3, Stereo pair of paratype free cheek (LACMIP 11882), not exfoliated, $\times 10.1$.

furrow bifurcated, directed slightly posteriorly, F2 and F3 furrows directed laterally, F4 furrow directed anteriorly. Occipital ring sagittal length 20–25% glabellar length, slightly elevated to not elevated above glabella, low convexity; occipital node; furrow curved anteriorly to straight, moderately deep; posterior margin slightly curved. Frontal area length 10–25% cranidial length, unequally divided. Preglabellar field slightly downsloping, length 15–35% frontal area length. Anterior border moderately to strongly convex, level to slightly downsloping, strongly tapering laterally, evenly curved, median inbend to no inbend, sagittal length 65–85% frontal area length. Anterior border furrow evenly curved, moderately narrow to wide, deep, as deep as axial furrows. Fixigena width, exclusive of palpebral lobe, 35–45% glabellar width, low convexity, downsloping, anterior area moderately downsloping. Palpebral lobe narrow, width 15–30% lobe length; short to moderate length, 20–35% glabellar length; anterior margin located adjacent to 15–25% glabellar length from anterior margin of

frontal lobe, level, furrow shallow. Ocular ridge weak, thin, directed moderately posterolaterally from glabella at 65–70° to axial trend. Posterior area of fixigena exsagittal width 30–50% glabellar length; length 45–55% glabella length; downsloping, roundly terminated. Posterior border high, strongly convex, uniform width, nodes present or absent; border furrow narrow, deep, straight, wider laterally.

Librigena small, length 3.7–4.2 mm; moderately wide, width 40–45% length without spine; lateral margin gently curved; moderate convexity, height 30–40% width. Genal field gently convex, width 50–60% librigenal width. Border width 25–35% librigenal width; gently convex; lateral border furrow narrow, shallow, shallowing posteriorly; posterior border furrow shallow, shallowing laterally. Genal spine short, 15–25% librigenal length.

Hypostoma and thorax unknown.

Pygidium small, length 2.8 mm; subelliptical, length approximately 60% width; margin smooth, anterior margin straight, curved posteriorly later-

ally; lateral margins evenly curved; posterior margin slightly flattened; moderate convexity (sag. and trans.), height approximately 50% width. Axis very slightly tapered, axial mid-width approximately 95% axial anterior width, axial anterior width approximately 40% pygidial width; axial length approximately 90% pygidial length, no postaxial ridge; 5 axial rings, high convexity; terminal axial piece rounded; axial and axial ring furrows deep to very shallow, deeper laterally. Pleural regions well defined, sagittally elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, deep, extends to border, strongly curved posteriorly; 4 additional pleural furrows, shallow to very shallow; interpleural furrows shallow to very shallow, joining with pleural furrows at border; anterior pleural bands weakly convex; posterior pleural bands moderately convex. Border narrow, width approximately 5% pygidial length; wider laterally, slightly convex, upturned laterally; border furrow absent.

Exoskeleton thin; smooth or fine granules on cranidia external surfaces; smooth on cranidia internal mold and pygidia external surfaces.

REMARKS. *Trachycheilus whirlwindensis* contains two subspecies, which are distinguished by the characteristics of their palpebral lobes, posterior area of fixigenae, and frontal areas. *Trachycheilus whirlwindensis whirlwindensis* occurs 2.0–0.5 m stratigraphically below *T. whirlwindensis drumensis* in the Drum Mountains. Because of the overall similarity of the two groups of specimens relative to other species of *Trachycheilus* and their close stratigraphic position, they are classified as two separate subspecies.

A single mature pygidium is known for the species. The pygidium is very similar to those belonging to *Elrathiella*, which occurs with *T. whirlwindensis*. This pygidium is assigned to *T. whirlwindensis* instead of *Elrathiella* because of a similar pygidium associated with *T. granulosus* at a locality where *Elrathiella* is not known. If these pygidia are properly assigned to *Trachycheilus*, then *Trachycheilus* belongs to the Ehmaniellinae.

Both subspecies differ from *T. typicalus* in having a less strong inbending of the anterior border, wider transverse length of the anterior border (55–75% of cranial width), straight posterior margin of occipital ring, occipital node, and less rounded frontal lobe. *Trachycheilus whirlwindensis* (s.l.) differs from *T. granulosus* in having non-granular ornamentation, shallower axial and lateral glabellar furrows, and a more subpentagonal outline for the cranidium.

ETYMOLOGY. Latinized, named after the Whirlwind Formation.

HOLOTYPE. Cranidium (LACMIP 11876) from the Whirlwind Formation, Drum Mountains, Utah (LACMIP locality 15468).

PARATYPES. See subspecies.

OTHER MATERIAL. LACMIP locality 15559, 11 cranidia, 2 pygidia, 1 librigena; also see subspecies.

OCCURRENCE. *Elrathiella* to *Ehmaniella* subzones, *Ehmaniella* Biozone. Pole Canyon Formation, Member E, Snake Range, Nevada; also see subspecies.

Trachycheilus whirlwindensis *whirlwindensis*, new subspecies

Figure 51

Trachycheilus, n. sp. Sundberg, 1991:388, fig. 2.16.

DIAGNOSIS. *Trachycheilus whirlwindensis* with cranidium with anterior border with very slight median inbend; wide anterior border furrow, palpebral lobes 28–37% glabellar length, posterior area of fixigenae 22–35% glabellar length with nodes on posterior border; frontal area 20–24% cranial length.

REMARKS. *Trachycheilus whirlwindensis whirlwindensis* differs from *T. whirlwindensis drumensis* in having generally longer palpebral lobes, narrower exsagittal width of the posterior area of fixigenae, nodes on posterior border, and a longer length of the frontal area.

ETYMOLOGY. Latinized, named after the Whirlwind Formation.

HOLOTYPE. Cranidium (LACMIP 11876) from the Whirlwind Formation, Drum Mountains, Utah (LACMIP locality 15468).

PARATYPES. LACMIP 11877–11882 from LACMIP locality 15468.

OTHER MATERIAL. LACMIP locality 15467, 9 cranidia, 5 librigenae; LACMIP locality 15468, 14 cranidia, 4 librigenae.

OCCURRENCE. *Elrathiella* Subzone, *Ehmaniella* Biozone. Whirlwind Formation, Drum Mountains, Utah.

Trachycheilus whirlwindensis *drumensis*, new subspecies

Figure 52

DIAGNOSIS. *Trachycheilus whirlwindensis* with cranidium with anterior border without median inbend; narrow anterior border furrow, palpebral lobes 22–29% glabellar length, posterior area of fixigenae 39–48% glabellar length without nodes on posterior border; frontal area 11–18% cranial length.

REMARKS. *Trachycheilus whirlwindensis drumensis* differs from *T. whirlwindensis whirlwindensis* in having generally shorter palpebral lobes, wider exsagittal width of the posterior area of fixigenae, no nodes on posterior border, and a shorter length of the frontal area.

ETYMOLOGY. Latinized, named after the Drum Mountains.

HOLOTYPE. Cranidium (LACMIP 11872) from the Whirlwind Formation, Drum Mountains, Utah (LACMIP locality 15470).

PARATYPES. LACMIP 11869–11871, 11873–11875 from LACMIP locality 15570.

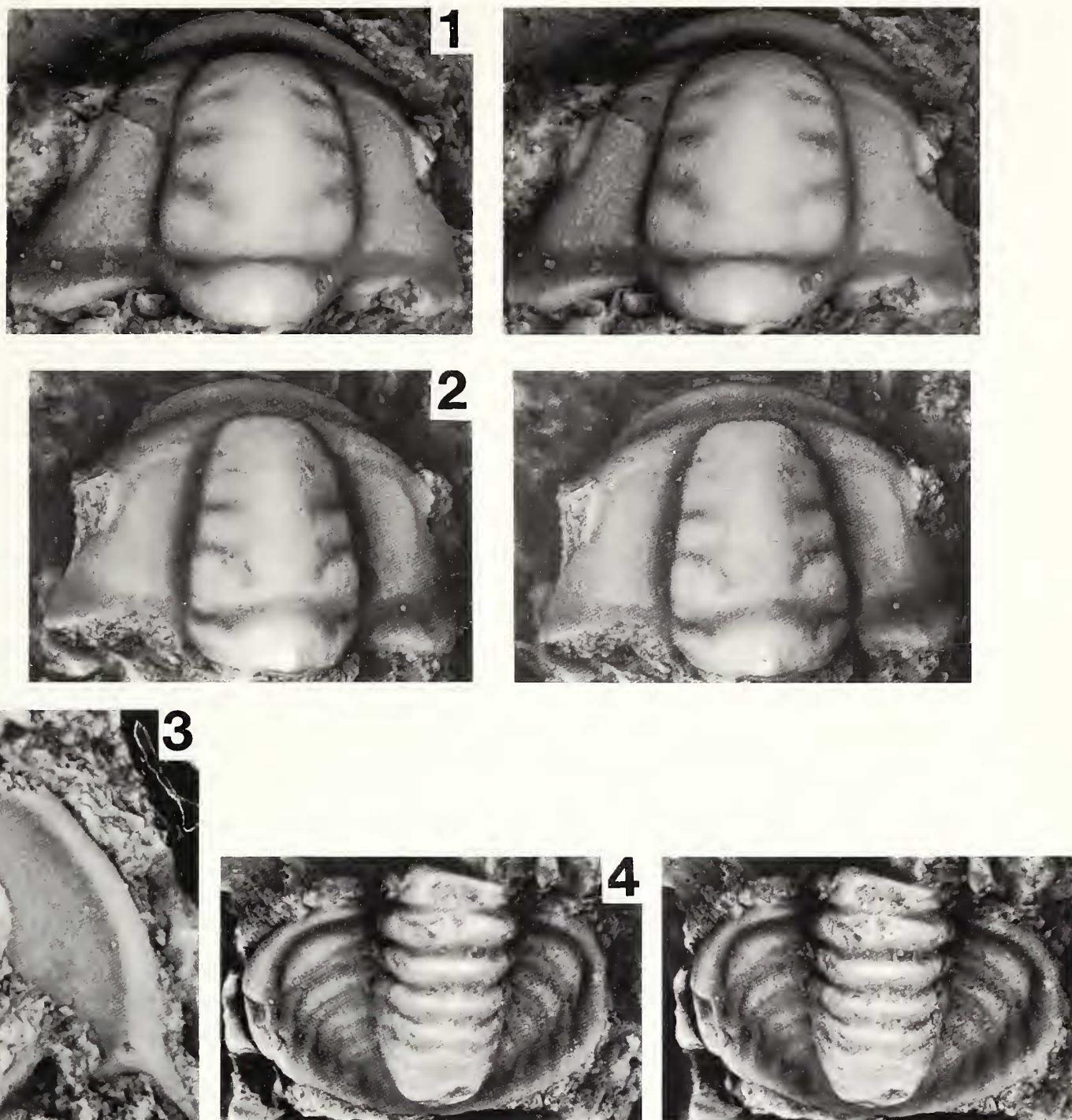


Figure 52. *Tachycheilus whirlwindensis drumensis*, new species and subspecies, LACMIP locality 15470. 1, Stereo pair of holotype cranidium (LACMIP 11872), slightly exfoliated, $\times 12.1$. 2, Stereo pair of paratype cranidium (LACMIP 11869), exfoliated, $\times 11.7$. 3, Paratype free cheek (LACMIP 11871), exfoliated, $\times 9.5$. 4, Stereo pair of large paratype pygidium (LACMIP 11875), not exfoliated, $\times 7.0$.

OTHER MATERIAL. LACMIP locality 15469, 40 cranidia, 1 librigena; LACMIP locality 15470, 129 cranidia, 4 pygidia, 7 librigenae; LACMIP locality 15522, 19 cranidia, 2 pygidia, 2 librigenae; LACMIP locality 15523, 77 cranidia, 1 pygidium; LACMIP locality 15579, 2 cranidia, 1 pygidium.

OCCURRENCE. *Elrathiella* to *Ehmaniella* subzones, *Ehmaniella* Biozone. Whirlwind Formation, Drum Mountains, Utah. Shadscale Formation, Dugway Range, Utah. Pole Canyon Limestone, Member E, Patterson Pass, Nevada.

Trachycheilus? sp. A
Figure 53

DESCRIPTION. Cranidium moderate size, length 7.1 mm; trapezoidal, length approximately 50% width; anterior margin slightly curved, anterior

margin width approximately 50% cranidial width; posterior margin, excluding occipital ring, slightly backswept. Facial sutures slightly convergent from ends of palpebral lobes; moderately divergent posterior of palpebral lobes. Glabella elongate, length approximately 80% and width approximately 65% cranidial length; glabella width approximately 35% cranidial width; strongly tapered, width at anterior end approximately 65% glabellar width; frontal lobe strongly rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, uniform depth, moderately convex; preglabellar furrow moderately shallow, not joining with anterior border furrow, narrow, moderately curved; lateral glabellar furrows shallow to moderately shallow, F1 furrow bifurcated, directed slightly posteriorly, F2 and F3 furrows directed laterally. Occipital ring sagittal length approximately 20% glabellar length; very small oc-

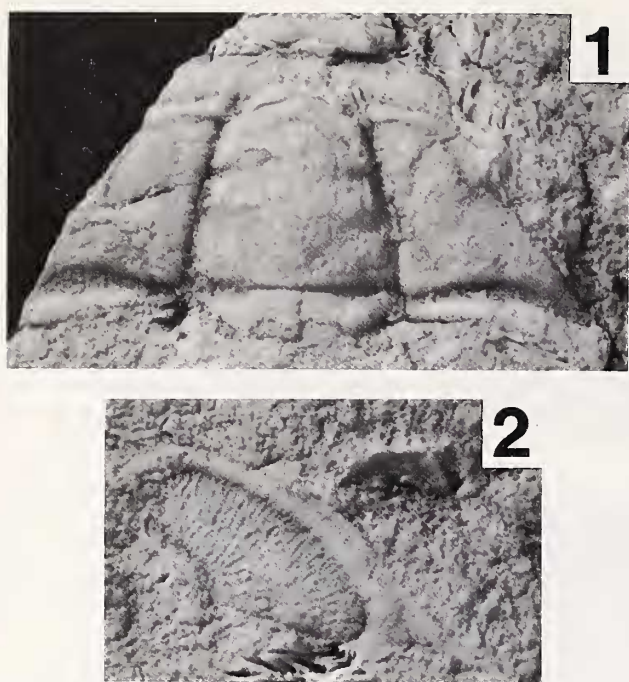


Figure 53. *Trachycheilus?* sp. A, exfoliated, LACMIP locality 15402. 1, Cranidium (LACMIP hypotype 11867), $\times 4.1$. 2, Free cheek (LACMIP 11868), $\times 4.0$.

capital node; furrow straight, moderate depth; posterior margin slightly curved. Frontal area length approximately 20% cranidial length, subequally divided. Preglabellar field length approximately 45% frontal area length. Anterior border strongly convex, not tapering laterally?, evenly curved, no median inbend, sagittal length 55% frontal area length. Anterior border furrow evenly curved, moderately narrow, moderate depth, as deep as axial furrows. Fixigena width, exclusive of palpebral lobe, approximately 40% glabellar width. Palpebral lobe narrow, width approximately 25% lobe length; short, length approximately 25% glabellar length; anterior margin located adjacent to approximately 15% glabellar length from anterior margin of frontal lobe, furrow shallow. Ocular ridge weak, thin, directed moderately posterolaterally from glabella at approximately 75° to axial trend. Posterior area of fixigena exsagittal width approximately 50% glabellar length; length approximately 80% glabella length; roundly terminated. Posterior border moderately high, moderately convex, wider laterally, nodes absent; border furrow narrow, deep, curved posteriorly, wider laterally.

Librigena moderate size, length 6.7 mm; moderately wide, width approximately 50% length without spine; lateral margin gently curved. Genal field width approximately 70% librigenal width. Border width approximately 25% librigenal width; convex; lateral border furrow narrow, shallow, shallowing posteriorly; posterior border furrow shallow, uniform depth. Genal spine short, approximately 25% librigenal length.

Hypostoma, thorax, and pygidium unknown.

Exoskeleton thickness unknown. Ornamentation radiating ridges on anterior area of fixigena and genal area of librigena; smooth on all other parts on internal surface.

REMARKS. *Trachycheilus?* sp. A is not assigned a trivial name because it is known only by two flattened specimens preserved in shale. The lateral portions of the anterior border are not preserved.

Trachycheilus? sp. A is the oldest known, potential representative of the genus, occurring in the lower *Ehmaniella* Biozone. *Trachycheilus?* sp. A differs from other species of *Trachycheilus* by the trapezoid outline of the cranidium, shallow lateral glabellar furrows, nearly straight anterior border, shallower axial furrows, longer posterior area of fixigenae, and perhaps a less inflated glabella. *Trachycheilus?* sp. A is questionably assigned to the genus based on its shallower axial and lateral glabellar furrows. In some respects, this species resembles *Proehmaniella basilica* (Fig. 45) in its glabellar shape (although somewhat wider), ocular ridges, palpebral lobes, and posterior area of fixigenae. *Trachycheilus?* sp. A differs from *P. basilica* in its convergent facial suture posterior of the palpebral lobes, narrower frontal area, wider occipital ring, and wider glabella. These similarities also suggest that *Trachycheilus* belongs in the *Ehmaniellinae*, although some similarities could be the result of compression of the specimens of the two species in the shales in which they occur.

HYPOTYPES. LACMIP 11867, 11868 from LACMIP locality 15502.

OCCURRENCE. *Proehmaniella* Subzone, *Ehmaniella* Biozone. Chisholm Formation, House Range, Utha.

Trachycheilus? sp. B

Figure 54

DESCRIPTION. Cranidium small to moderate size, length 3.8 mm; subtrapezoidal, moderate convexity (sag. and trans.); anterior margin moderately, unevenly curved, flattened laterally; posterior margin, excluding occipital ring, straight. Facial sutures moderately convergent from ends of palpebral lobes to middle of anterior border; moderately strong convergence across anterior half of anterior border; moderately strong divergence posterior of palpebral lobes. Glabella elongate, length approximately 80% and width approximately 60% cranidial length; strongly tapered, width at anterior end approximately 70% glabella width; moderately high convexity (sag. and trans.); frontal lobe slightly flattened, 3 lateral glabellar lobes. Axial furrows very deep, uniform depth, slightly convex; preglabellar furrow moderately deep, joining with anterior border furrow, narrow, moderately curved; lateral glabellar furrows moderately shallow; F1 furrow moderate depth, bifurcated, directed slightly posteriorly, F2 and F3 furrows moderately shallow depth, directed laterally. Occipital ring sagittal length approximately 30% glabellar length; elevated slightly above glabella, moderate convexity; small occipital node; furrow curved anteriorly, deep; posterior margin moderately curved. Frontal area length approximately 20% cranidial length, unequally divid-



Figure 54. *Trachycheilus?* sp. B. Stereo pair of partial cranidium (LACMIP hypotype 11866), LACMIP locality 15600, partially exfoliated, $\times 8.4$.

ed. Preglabellar field approximately 30% frontal area, slightly convex, downsloping. Anterior border strongly convex, level, moderately tapering laterally, flattened laterally, no median inbend, sagittal length approximately 70% frontal area length. Anterior border furrow straight laterally, moderately wide, deep, as deep as or slightly shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, approximately 40% glabellar width, moderate convexity, slightly downsloping, anterior area strongly downsloping. Palpebral lobe narrow, width approximately 25% lobe length; short, length approximately 30% glabellar length; anterior margin located adjacent to approximately 20% glabellar length from anterior margin of frontal lobe, level furrow shallow. Ocular ridge very weak to absent, thin, directed slightly posterolaterally from glabella at approximately 80° to axial trend. Posterior area of fixigena poorly preserved.

Hypostoma, librigena, thorax, and pygidium unknown.

Exoskeleton moderately thick. Smooth on cranidium external surface and internal mold.

REMARKS. Two fragmentary specimens are questionably assigned to *Trachycheilus* because of narrower posterior area of fixigenae and thicker exoskeletons than is typical of the genus. These specimens also resemble *Modocia brevispina* Robison, 1964a, in the narrow posterior area of fixigenae, small palpebral lobes, nearly effaced ocular ridges, fixigenal convexity and width, and other cranidial aspects. *Trachycheilus?* sp. B differs from *Modocia* in having a more elevated glabella, slightly flattened frontal lobe, and larger occipital ring. The librigenae and pygidium of *Trachycheilus?* sp. B are unknown, thus comparison to the librigenae and pygidia of *Modocia* is not possible. The similarity between *Trachycheilus?* sp. B to other species of *Trachycheilus* and *Modocia* suggests a close relationship of Ehmaniellidae and Marjumiidae.

HYPOTYPES. LACMIP 11866 from LACMIP locality 15600.

OTHER MATERIAL. LACMIP locality 15600, 1 cranidium.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Eldorado Formation, northern Egan Range, Nevada.

Genus *Tympanuella*, new genus

TYPE SPECIES. *Tympanuella transversa*, new species.

DIAGNOSIS. Ehmaniellinae with subrectangular cranidium with divergent facial sutures anterior of palpebral lobes; moderate to long palpebral lobes (35–45% glabellar length); well-defined anterior border, moderately narrow (10–15% cranidial length), slightly to moderately tapered; preglabellar field sagittally moderately wide (50–55% frontal area length); slightly tapered glabella; moderately rounded frontal lobe; exsagittally narrow posterior area of fixigenae (20–35% glabellar length). Pygidium subtriangular with elongate axis, 4 axial rings; moderate depth pleural furrows; moderately convex anterior and posterior pleural bands.

REMARKS. *Tympanuella* is monospecific and is distinguished from *Elrathiella* in having a less tapered glabella, moderately rounded frontal lobe, and weakly tapered anterior border. *Tympanuella* can be distinguished from *Ehmaniella* in having a generally less tapered glabella and a rounded frontal lobe. *Tympanuella* differs from *Proehmaniella* in its less tapered glabella, transversely narrower anterior border, narrower preglabellar field, and subtriangular pygidium with four axial rings and deeper pleural furrows. *Tympanuella* occurs in the middle *Ehmaniella* Biozone.

ETYMOLOGY. Latin, *tympanum* = drum, for the Drum Mountains.

Tympanuella transversa, new species

Figure 55

“ehmaniellid,” n. gen. et n. sp. Sundberg, 1991:388, fig. 2.19.

DIAGNOSIS. Same as genus.

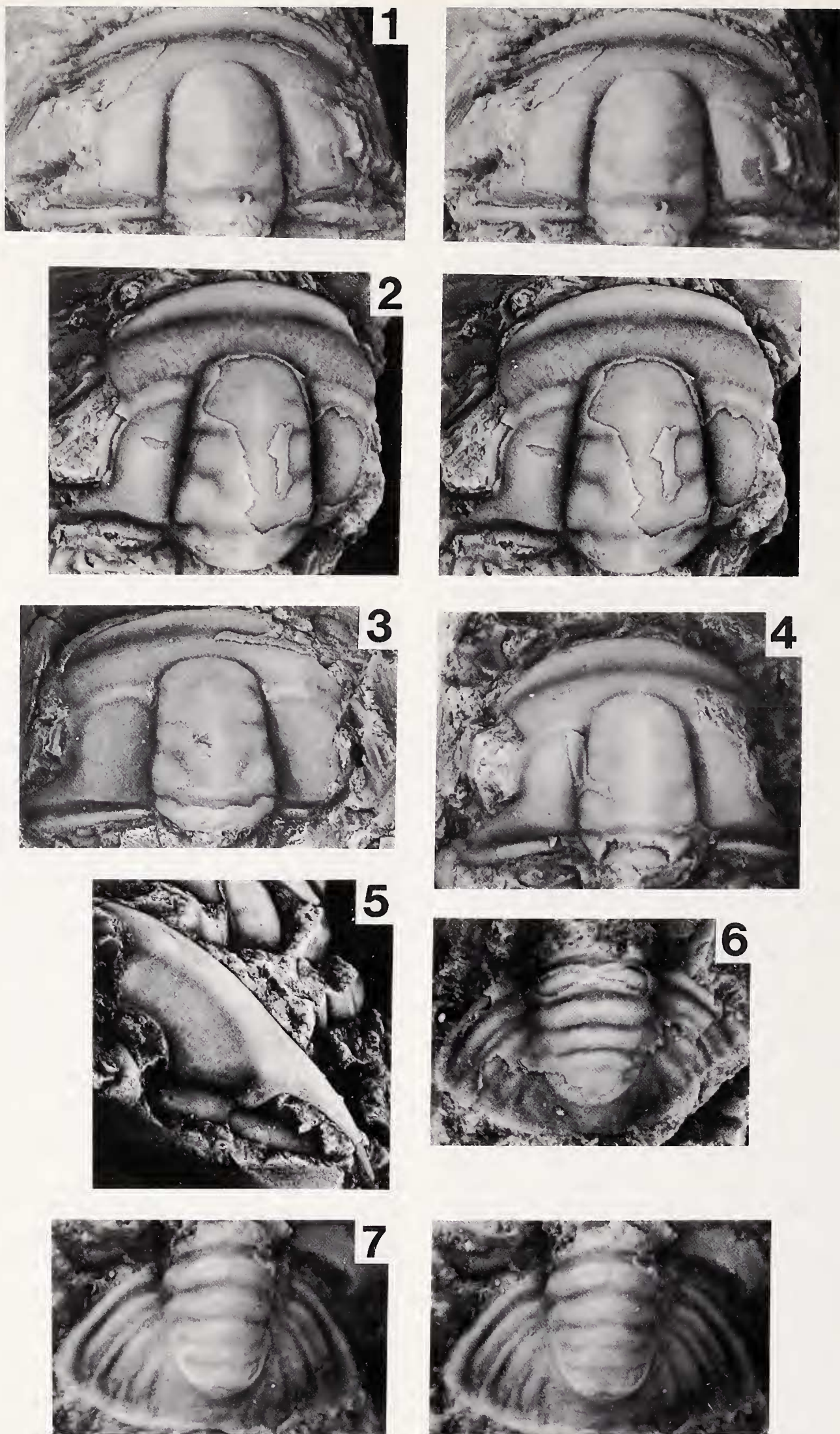


Figure 55. *Tympanuella transversa*, new genus and species, LACMIP locality 15472. 1, Stereo pair of holotype cranidium (LACMIP 11906), exfoliated, $\times 5.2$. 2, Stereo pair of paratype cranidium (LACMIP 11885), partially exfoliated, $\times 6.7$. 3, Paratype cranidium (LACMIP 11884), exfoliated, $\times 3.7$. 4, Paratype cranidium (LACMIP 11895), exfoliated, $\times 6.2$. 5, Paratype free cheek (LACMIP 11898), exfoliated, $\times 6.1$. 6, Paratype pygidium (LACMIP 11892), partially exfoliated, $\times 10.8$. 7, Stereo pair of paratype pygidium (LACMIP 11890), exfoliated, $\times 8.5$.

DESCRIPTION. Cranidium moderate size, length 4.2–8.5 mm; rectangular, length 55–75% width; moderate convexity (sag. and trans.), height 20–30% width; anterior margin slightly curved, anterior margin width 70–80% cranial width; posterior margin, excluding occipital ring, very slightly back-swept to straight. Facial sutures slightly divergent from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 75–80% and width 50–60% cranial length; glabella width 35–40% cranial width; moderately tapered, width at anterior end 80–85% glabellar width; moderate convexity (sag. and trans.); frontal lobe moderately rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, slightly deeper posteriorly, very slightly convex; preglabellar furrow moderate depth laterally, shallow medially, moderately curved; lateral glabellar furrows shallow, F1 furrow bifurcated, directed posteriorly, F2 furrow directed slightly posteriorly, F3 furrow directed slightly anteriorly. Occipital ring sagittal length 15–20% glabellar length; not to slightly elevated above glabella, slightly convex; small occipital node; furrow curved posteriorly, moderately deep laterally, shallowing medially, moderate to shallow depth; posterior margin slightly curved. Frontal area length 20–25% cranial length, equally divided. Preglabellar field slightly convex, moderately downsloping, length 50–55% frontal area length. Anterior border strongly convex, level, slightly to strongly tapering laterally, evenly curved, sagittal length 45–50% frontal area length. Anterior border furrow evenly curved, moderate depth, slightly shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 45–70% glabellar width, low convexity, slightly upsloping. Palpebral lobe narrow, width 25–30% lobe length; moderate length to long, length 35–45% glabellar length; anterior margin located adjacent to 20–25% glabellar length from anterior margin of frontal lobe; furrow shallow. Ocular ridge strong to moderate strength, arched anteriorly, directed strongly to moderately posterolaterally from glabella at 65–75° to axial trend. Posterior area of fixigena exsagittal width 25–35% glabellar length; length 50–80% glabella length; sharply terminated. Posterior border moderately high, strongly convex, distally wider; border furrow narrow, deep, straight, wider laterally.

Librigena moderate size, length 7.0 mm; moderately wide, width approximately 60% length without spine; lateral margin slightly curved; height approximately 35% width. Genal field gently convex, width approximately 50% librigenal width. Border width approximately 25% librigenal width; moderately convex; lateral border furrow shallow, shallowing posteriorly; posterior border furrow moderately deep, shallowing laterally. Genal spine moderate length, approximately 70% length.

Hypostoma and thorax unknown.

Pygidium small, length 2.0–2.8 mm; subtrian-

gular to subelliptical, length 50–55% width; margin smooth, anterior margin strongly curved posteriorly; lateral margins evenly curved; posterior margin slightly flattened; moderate convexity (sag. and trans.), height 35–50% width. Axis slightly tapered, axial mid-width approximately 90% axial anterior width, axial anterior width 35–45% pygidial width; axial length 75–80% pygidial length, no postaxial ridge; 4 axial rings, high convexity; terminal axial piece strongly rounded; axial furrow shallow; axial ring furrows moderate to shallow depth, deeper laterally. Pleural regions well defined, sagittally elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, moderately deep, extends to margin, curved strongly posterior; 3 additional pleural furrows, moderate depth to shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows near margin; anterior pleural bands moderately convex; posterior pleural bands moderately convex. Border narrow, width 5–10% pygidial length, slightly widening laterally; flat, upturned; border furrow absent.

Exoskeleton thin; genal caeca on preglabellar field, anterior area of fixigena, and genal area of librigenae on external and internal surfaces; other parts smooth.

REMARKS. *Tympanuella transversa* is variable in the width of the fixigenae, width of cranidia, depth of lateral glabellar furrows, arching of ocular ridges, length of pygidial axis, and outline of the pygidia. The various morphological types are included in a single species because of their occurrence within the same stratigraphic level or in close stratigraphic proximity (LACMIP localities 15472–15473).

ETYMOLOGY. Latin, *transversa* = crosswise, for the “crosswise” elongation of the pygidium.

HOLOTYPE. Cranidium (LACMIP 11906) from the Whirlwind Formation, Drum Mountains, Utah (LACMIP locality 15472).

PARATYPES. LACMIP 11884–11905 from LACMIP locality 15472.

OTHER MATERIAL. LACMIP locality 15468, 1? cranidium; LACMIP locality 15472, 32 cranidia, 12 librigenae; LACMIP locality 15473, 120 cranidia, 10 pygidia, 6 librigenae; LACMIP locality 15474, 4 cranidia, 9 pygidia, 3 librigenae; LACMIP locality 15509, 106 cranidia, 54 pygidia, 12 librigenae; LACMIP locality 15510, 29 cranidia, 11 pygidia, 5 librigenae; LACMIP locality 15511, 63 cranidia, 19 pygidia, 11 librigenae; LACMIP locality 15521, 11? cranidia, 1? pygidium, 2? librigenae; LACMIP locality 15525, 7 cranidia, 7 pygidia, 6 librigenae; LACMIP locality 15555, 35 cranidia, 1 pygidium; LACMIP locality 15556, 13 cranidia, 2 pygidia, 1 librigena; LACMIP locality 15557, 17 cranidia, 5 pygidia, 11 librigenae; LACMIP locality 15559, 1 cranidium.

OCCURRENCE. *Elrathiella* to *Ehmaniella* subzones, *Ehmaniella* Biozone. Whirlwind Formation, Drum Mountains and House Range, Utah. Shadscale Formation, Dugway Range, Utah. Pole Canyon Limestone, Member E, Snake Range, Nevada.



Figure 56. Ehmaniellinae sp. A. Stereo pair of cranium (LACMIP hypotype 11960), LACMIP locality 15590, exfoliated, $\times 8.3$.

Genus Uncertain

Ehmaniellinae sp. A

Figure 56

DESCRIPTION. Cranium small, length 4.0 mm; subpentagonal, length approximately 70% width; moderate convexity (sag. and trans.), height approximately 25% width; anterior margin moderately curved, anterior margin width approximately 75% cranial width; posterior margin, excluding occipital ring, slightly backswept. Facial sutures moderately divergent from ends of palpebral lobes to anterior border furrow; strongly convergent across anterior border; very strongly divergent posterior of palpebral lobes. Glabella elongate, length approximately 75% and width approximately 50% cranial length; glabella width approximately 35% cranial width; strongly tapered, width at anterior end, approximately 70% glabellar width; low convexity (sag. and trans.), slight medial ridge; frontal lobe bluntly rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, deeper posteriorly, slightly concave; prelabellar furrow moderately shallow, moderately curved; lateral glabellar furrows very shallow, F1 furrow bifurcated, directed posteriorly, F2 furrow directed slightly posteriorly, F3 furrow directed slightly anteriorly. Occipital ring sagittal length approximately 20% glabellar length, very slightly elevated above glabella, slightly convex; very small occipital node; furrow straight, deeper lateral shallowing medial, moderate to shallow depth; posterior margin curved. Frontal area length approximately 25% cranial length, unequally divided. Preglabellar field slightly convex, downsloping, length approximately 25% frontal area length. Anterior border slightly convex, slightly downsloping, moderately tapering laterally, undulatory margin, sagittal length approximately 75% frontal area length. Anterior border furrow undulatory, moderately shallow, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, approximately 45% glabellar width, low convexity, slightly upsloping. Palpebral lobe narrow, width approximately 25% lobe length; long, length approximately 50% glabellar length; anterior margin located adjacent to approximately 20% glabellar

length from anterior margin of frontal lobe; furrow moderately deep. Ocular ridge front relief, directed moderately posterolaterally from glabella at 65° to axial trend. Posterior area of fixigena exsagittal width approximately 20% glabellar length; length approximately 70% glabella length; sharply terminated. Posterior border strongly convex, slightly widening laterally; border furrow moderately narrow, deep, curved posterolaterally, wider slightly laterally.

Libregena, hypostoma, thorax, and pygidium unknown.

Exoskeleton thin?; scattered granules on fixigena, glabella, occipital ring, genal caeca on prelabellar field and anterior area of fixigena on internal mold.

REMARKS. Ehmaniellinae sp. A is represented by only one well-preserved cranium. It superficially resembles *Pseudomexicella hestia* (Fig. 49) in its glabellar outline and downsloping anterior border. However, Ehmaniellinae sp. A is not placed in *Pseudomexicella* because of its similarity to juveniles of *Ehmaniella fronsplanata* (Fig. 35.4) in glabellar outline, long palpebral lobes, distribution of granules on the fixigena and glabella, and undulatory anterior border furrow. This suggests that Ehmaniellinae sp. A may have been derived from *E. fronsplanata* and that its similarity to *Pseudomexicella* resulted from convergence. Nomenclature of this species is left open because it is known only from a single specimen.

HYPOTYPE. LACMIP 11960 from LACMIP locality 15590.

OCCURRENCE. *Ehmaniella* Subzone, *Ehmaniella* Biozone. Eldorado Formation, northern Egan Range, Nevada.

Ehmaniellinae sp. B

Figure 57

DESCRIPTION. Pygidium small, length 2.8 mm; transversely elongate, length approximately 50% width; margin smooth, anterior margin slightly to moderately curved posteriorly; lateral margins slightly flattened; posterior margin slightly flattened; low to moderate convexity (sag. and trans.), height approximately 30% width. Axis slightly ta-

pered, axial mid-width approximately 90% axial anterior width, axial anterior width approximately 35% pygidial width; axial length approximately 70% pygidial length, no postaxial ridge; 4 axial rings, high convexity; terminal axial piece bluntly rounded; axial furrow shallow; axial ring furrows moderate to shallow depth, deeper laterally. Pleural regions well defined, sagittally elongate, triangularly shaped; low convexity, downsloping; anterior pleural furrow narrow, moderately deep, extends to margin, curved strongly posterior; 3 additional pleural furrows, moderate depth to shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows near border; anterior and posterior pleural bands moderately convex. Border narrow, width approximately 10% pygidial length, uniform width; flat, level; border furrow absent.

Exoskeleton thin; smooth on external and internal surfaces.

REMARKS. Two types of pygidia are associated with cranidia of two subspecies of *Ehmaniella fronsplanata*. The pygidial type selected to be associated with *E. fronsplanata* is the more common of the two types and possesses a relatively sagittally shorter pygidial length and a longer axis. *Ehmaniellinae* sp. B is the other associated pygidium that is sagittally longer and has a short, blunt axis. It is possible that this pygidial type belongs to *E. fronsplanata* instead of or in addition to the long-axis pygidial type.

HYPOTYPES. LACMIP 12007 from LACMIP locality 15483; LACMIP 12008 from LACMIP locality 15478.

OTHER MATERIAL. LACMIP locality 15477, 2 pygidia; LACMIP locality 15482, 1 pygidium; LACMIP locality 15483, 1 pygidium.

OCCURRENCE. *Ehmaniella* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountain, Utah.

Subfamily Altiocculinae, new subfamily

TYPE GENUS. *Altiocculus*, new genus.

REMARKS. Altiocculinae is characterized by cranidia with (1) well-defined, relatively short (55–65% cranidial length), strongly to very strongly tapered glabella with moderate to deep axial furrows, moderate depth lateral glabellar furrows, rounded to truncated frontal lobes; (2) moderate to small palpebral lobes; (3) moderate to weak ocular ridges; (4) relatively strong downsloping anterior area of fixigena; (5) transversely elongated medial swelling in the frontal area; and (6) granular ornamentation. This subfamily differs from *Ehmaniellinae* in having a relatively short glabella, steeply downsloping of the preglabellar field and anterior area of fixigena, and a medial swelling in the frontal area. Taxa assigned to Altiocculinae include *Altiocculus*, *Pseudalokistocare*, and *Schopfaspis*.

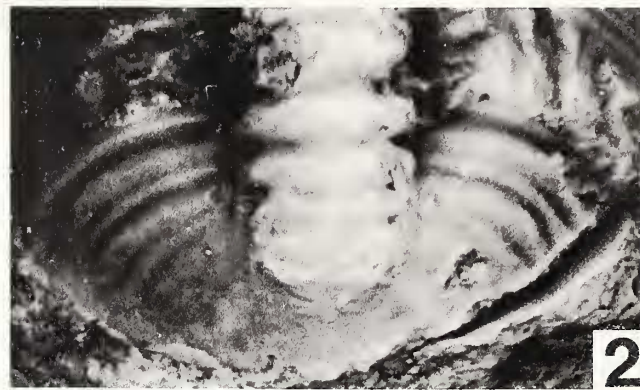
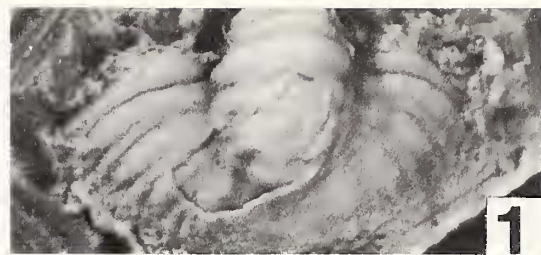


Figure 57. *Ehmaniellinae* sp. B. 1, Pygidium (LACMIP hypotype 12007), LACMIP locality 15483, partially exfoliated, $\times 6.6$. 2, Pygidium (LACMIP hypotype 12008), LACMIP locality 15478, exfoliated, $\times 9.3$.

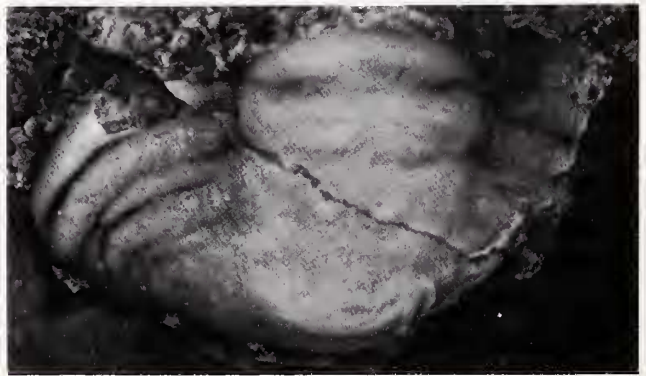
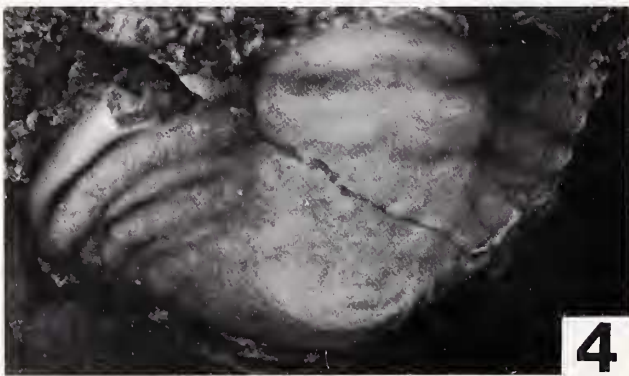
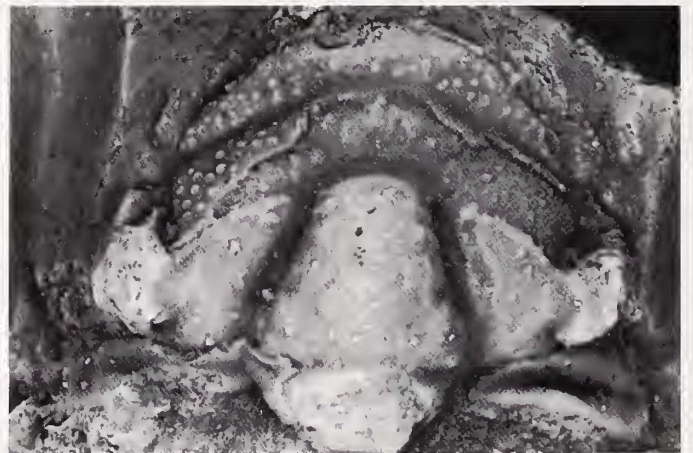
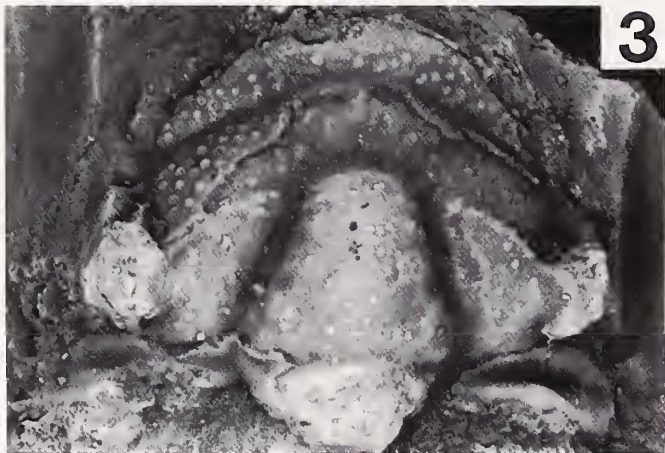
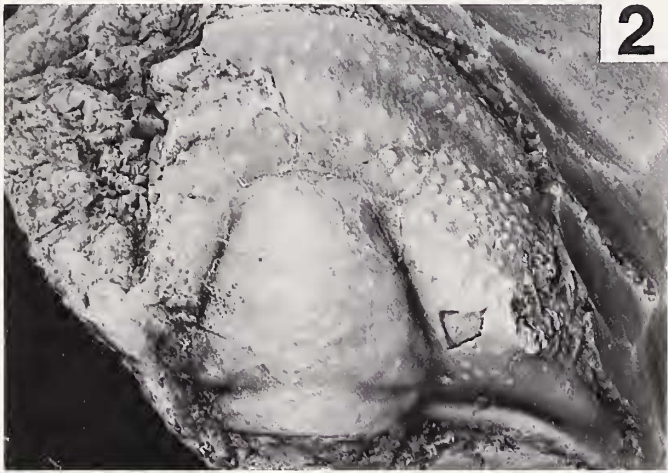
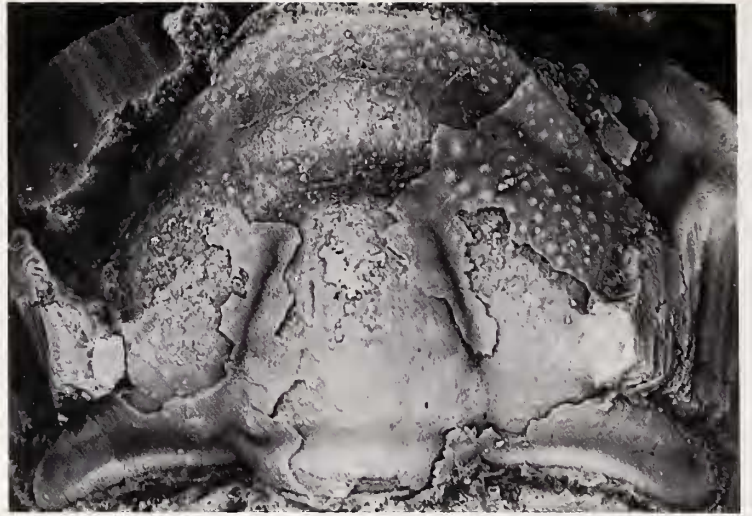
Genus *Altiocculus*, new genus

TYPE SPECIES. *Altiocculus drumensis*, new species.

DIAGNOSIS. Large, micropygous Altiocculinae with cranidium with typically moderate length (20–30% glabellar length), posteriorly set, elevated palpebral lobes; strongly downsloping anterior area of fixigena; very strongly tapered glabella; median swelling posterior of anterior border furrow; no deep pits in anterior border furrow; secondary preoccipital lobes; narrow posterior area of fixigena (15–30% glabellar length); coarse granular ornamentation. Pygidium subelliptical; transversely elongate; narrow, level border; moderately to moderately weak convex anterior pleural bands; strongly convex posterior pleural bands.

REMARKS. *Altiocculus* is easily distinguished from the other genera in Altiocculinae by its elevated palpebral lobes relative to the posterior area of fixigena and anterior border, coarse granulation, median swelling posterior of the anterior border furrow, and very strongly tapered glabella.

Altiocculus contains some species that have been previously assigned to *Alokistocare*. However, the genus differs from *Alokistocare subcoronatum*, the type species of *Alokistocare*, in its absence of a rounded median swelling occurring in both the preglabellar field and anterior border area, strongly downsloping anterior area of the fixigena, more posteriorly placed palpebral lobes, narrower and longer posterior area of fixigena, coarse granular ornamentation, and more elevated palpebral lobes relative to the posterior area of fixigena and anterior border. *Altiocculus* differs from other species of *Alokistocare* by having several of the differences listed above and the pygidium having a subelliptical



outline, pleural and interpleural furrows joining near the margin, and moderately developed anterior and posterior pleural bands.

Previously named species assigned to *Altiocculus* include: *Alokistocare harrisi* Robison, 1971, and *A. harrisi?* of the Wheeler Shale or Marjum Formation of Utah; *A. sinuatum* Rasetti, 1951, and *A. cataractense* Rasetti, 1951, of the Eldon Formation of British Columbia; and *A. americanum* (Walcott, 1916; Schwimmer, 1989) from the Appalachians. New species include: *A. drumensis* and *A. concavus* from the Swasey Limestone of Utah; and *A. cf. A. harrisi* from the Eldorado Formation of Nevada. Species of *Altiocculus* are differentiated primarily on the construction of their frontal area.

Alokistocare harrisi is the only species of *Altiocculus* that is known from complete exoskeletons. The holaspid specimens have consistently 32 thoracic segments, 9 more than *Alokistocare* species (Robison, 1971). However, this species is not used as the type species because the specimens are compressed in shales and they do not retain their original convexity (Robison, 1971; personal observations).

Altiocculus occurs in the *Altiocculus* Subzone of the *Ehmaniella* Biozone to the lower *Bolaspidella* Biozone.

ETYMOLOGY. Latin, *altus* = high, elevated, *occulus* = eyes.

***Altiocculus drumensis*, new species**

Figure 58

New genus #2 Sundberg 1991:388, fig. 2.15.

DIAGNOSIS. *Altiocculus* with subpentagonal cranidium with median swelling extending from preglabellar furrow to anterior furrow; unevenly, strongly curved, strongly tapered, flat, level anterior border; shallow, relatively narrow, anterior border furrow, slightly convex axial furrows in larger specimens; posterior area of fixigenae with rounded terminations. Pygidium subelliptical with moderately convex anterior pleural bands, strongly convex posterior pleural bands.

DESCRIPTION. Cranidium large, length 8.0–18.7 mm; subpentagonal, length 55–75% width; moderate convexity (sag. and trans.), height 25–35% width; anterior margin strongly, unevenly curved, anterior margin width 65–75% cranial width; posterior margin, excluding occipital ring, slightly to moderately backswept. Facial sutures

moderately divergent from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of anterior border; strongly divergent posterior of palpebral lobes. Glabella moderate length, length 60–65% and width 50–65% cranial length; glabella width 30–40% cranial width; very strongly tapered, width at anterior end 55–60% glabellar width; moderate convexity (sag. and trans.); anterior end moderately rounded, 3 lateral glabellar lobes, secondary preoccipital lobes. Axial furrows moderately deep, deeper posteriorly, slightly convex in larger specimens, concave in smaller specimens; preglabellar furrow moderately deep, broad, moderately curved; lateral glabellar furrows very shallow, F1 furrow bifurcated, directed posteriorly, F2 and F3 furrows directed slightly anteriorly. Occipital ring sagittal length 20–25% glabellar length, slightly elevated above glabella, moderately convex; no occipital node or spine; furrow curved anteriorly, moderate depth laterally, shallow medially; posterior margin very slightly curved. Frontal area length 35–40% cranial length, unequally divided. Preglabellar field possesses transversely elongate, moderately convex, median swelling; slightly downsloping to level; length 60–70% frontal area length. Anterior border flat, level, strongly tapering laterally, unevenly curved, straighter laterally, sagittal length 30–40% frontal area length. Anterior border furrow unevenly curved, straighter laterally, moderately narrow, shallow, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 45–50% glabellar width, moderate to low convexity, upsloping, anterior area strongly downsloping. Palpebral lobe narrow to moderate width, width 25–35% lobe length; short, length 20–30% glabellar length; anterior margin located adjacent to 35–40% glabellar length from anterior margin of frontal lobe; higher than adjacent cranial features, upturned, furrow very shallow. Ocular ridge weak, thin, directed strongly posterolaterally from glabella at 55–60° to axial trend. Posterior area of fixigena exsagittal width 25–30% glabellar length; length 75–90% glabella length; downsloping, roundly terminated. Posterior border high, strongly convex, uniform width; border furrow narrow, deep, curved posteriorly, wider laterally.

Librigena large, length 20.1 mm; moderately wide, width approximately 60% length without spine; lateral margin gently curved. Genal field gently convex, width approximately 60% librigenal width.

Figure 58. *Altiocculus drumensis*, new genus and species, LACMIP locality 15492. 1, Stereo pair of holotype cranidium (LACMIP 11916), partially exfoliated, ×2.5. 2, Stereo pair of partial, paratype cranidium (LACMIP 11915), slightly exfoliated, ×2.0. 3, Stereo pair of small paratype cranidium (LACMIP 11917), exfoliated, ×4.6. 4, Stereo pair of partial, paratype pygidium (LACMIP 11921), exfoliated, ×10.8. 5, Stereo pair of paratype pygidium (LACMIP 11920), not exfoliated, ×6.8.

Border width approximately 25% librigenal width; gently convex; lateral border furrow shallow, shallowing posteriorly; posterior border furrow shallow, shallowing laterally. Genal spine unknown.

Hypostoma and thorax unknown.

Pygidium small, length 2.6–3.5 mm; subelliptical, length 40–50% width; margin smooth, anterior margin moderately curved posteriorly; lateral margins evenly curved; posterior margin moderately rounded; moderate convexity (sag. and trans.), height 35–45% width. Axis slightly to moderately tapered, axial mid-width 80–90% axial anterior width, axial anterior width approximately 40% pygidial width; axial length 85–95% pygidial length, no postaxial ridge; 3 axial rings, moderately low convexity; terminal axial piece rounded; axial and axial ring furrows shallow, uniform depth. Pleural regions well defined, sagittally elongate, triangularly shaped; low convexity, slightly downsloping; anterior pleural furrow narrow, moderately deep, extends to margin, slightly curved posteriorly, moderately curved laterally; 2 additional pleural furrows, moderate depth; interpleural furrows moderate depth to shallow, joining with pleural furrows at border; anterior pleural bands moderately convex; posterior pleural bands strongly convex. Border narrow, width approximately 5% pygidial length; slightly convex, downsloping; border furrow absent.

Exoskeleton thin; scattered coarse granules on glabella, median swelling, palpebral area and posterior area of fixigena; denser coarse granules on anterior border and anterior area of fixigena, librigenae; smooth on anterior border furrow, lateral portion of posterior area of fixigenae, and pygidia on external and internal surfaces.

REMARKS. Larger specimens of *Altiocculus drumensis* differ from all other species of *Altiocculus* in possessing convex axial furrows. Smaller specimens of *A. drumensis* have concave axial furrows, which are more typical of the genus. In general, *A. drumensis* differs from all other species of *Altiocculus* in its subpentagonal shape and the rounded terminations of the posterior area of fixigenae. Specimens from the Eldorado Formation in the northern Egan Range are questionably assigned to *A. drumensis* because they have upturned anterior borders, although the specimens are not abundant and poorly preserved. This difference in the anterior border may represent intraspecific variation.

ETYMOLOGY. Latinized, named after the Drum Mountains.

HOLOTYPE. Cranidium (LACMIP 11916) from the Swasey Limestone, Drum Mountains, Utah (LACMIP locality 15492).

PARATYPES. LACMIP 11915, 11917–11921, 11991 from LACMIP locality 15492.

OTHER MATERIAL. LACMIP locality 15490, 3 cranidia, 2 pygidia; LACMIP locality 15491, 1 cranidium; LACMIP locality 15492, 2 cranidia; LACMIP locality 15493, 2 cranidia, 2 pygidia; LACMIP locality 15494, 2 cranidia; LACMIP locality 15528, 1 cranidium, 1 pygid-

ium; LACMIP locality 15529, 1 cranidium; LACMIP locality 15530, 1 cranidium; LACMIP locality 15535, 2 cranidia; LACMIP locality 15560, 1 cranidium; LACMIP locality 15595, 1? cranidium; LACMIP locality 15598, 6? cranidia, 3? pygidia.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains, Utah. Trailer Limestone, Dugway Range, Utah. ?Eldorado Formation, northern Egan Range, Nevada. Pole Canyon Limestone, Member E, Snake Range, Nevada.

Altiocculus concavus, new species

Figure 59

DIAGNOSIS. *Altiocculus* with hemicircular cranidium with low relief, median swelling extending from preglabellar furrow to anterior furrow; evenly, strongly curved, slightly tapered, strongly convex, level anterior border; deep, relatively wide, anterior border furrow; posterior area of fixigenae with sharp terminations. Pygidium subelliptical with strongly recurved pleural and interpleural furrows near margin, furrows reach margin; moderately weak convex anterior pleural bands, moderately convex posterior pleural bands.

DESCRIPTION. Cranidium large, length 5.3–11.1 mm (larger specimens incomplete); hemicircular, length 80–85% width; moderate convexity (sag. and trans.), height approximately 30% width; anterior margin strongly, evenly curved, anterior margin width 80–90% cranidial width; posterior margin, excluding occipital ring, straight to moderately backswept. Facial sutures moderately divergent from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of anterior border; strongly divergent posterior of palpebral lobes. Glabella moderate length, length 55–60% and width 40–50% cranidial length; glabella width 35–40% cranidial width; very strongly tapered, width at anterior end 55–65% glabellar width; moderate convexity (sag. and trans.); anterior end moderately rounded to flattened, 3 lateral glabellar lobes, secondary preoccipital lobes. Axial furrows moderately deep, deeper posteriorly, concave; preglabellar furrow shallow, narrow, moderately curved, shallower medially; lateral glabellar furrows very shallow, F1 furrow bifurcated, directed posteriorly, F2 and F3 furrows directed slightly posteriorly. Occipital ring sagittal length 15–20% glabellar length, slightly elevated above glabella, moderately convex; no occipital node or spine; furrow curved anteriorly, moderate depth laterally, shallow medially; posterior margin very slightly curved. Frontal area length 40–45% cranidial length, unequally divided. Preglabellar field possesses transversely elongate, median swelling; low convexity; slightly downsloping; length 65–70% frontal area length. Anterior border convex, flat dorsally, level, very slightly tapering laterally, evenly curved, sagittal length 30–35% frontal area length. Anterior border furrow evenly curved, wide, narrowing lat-

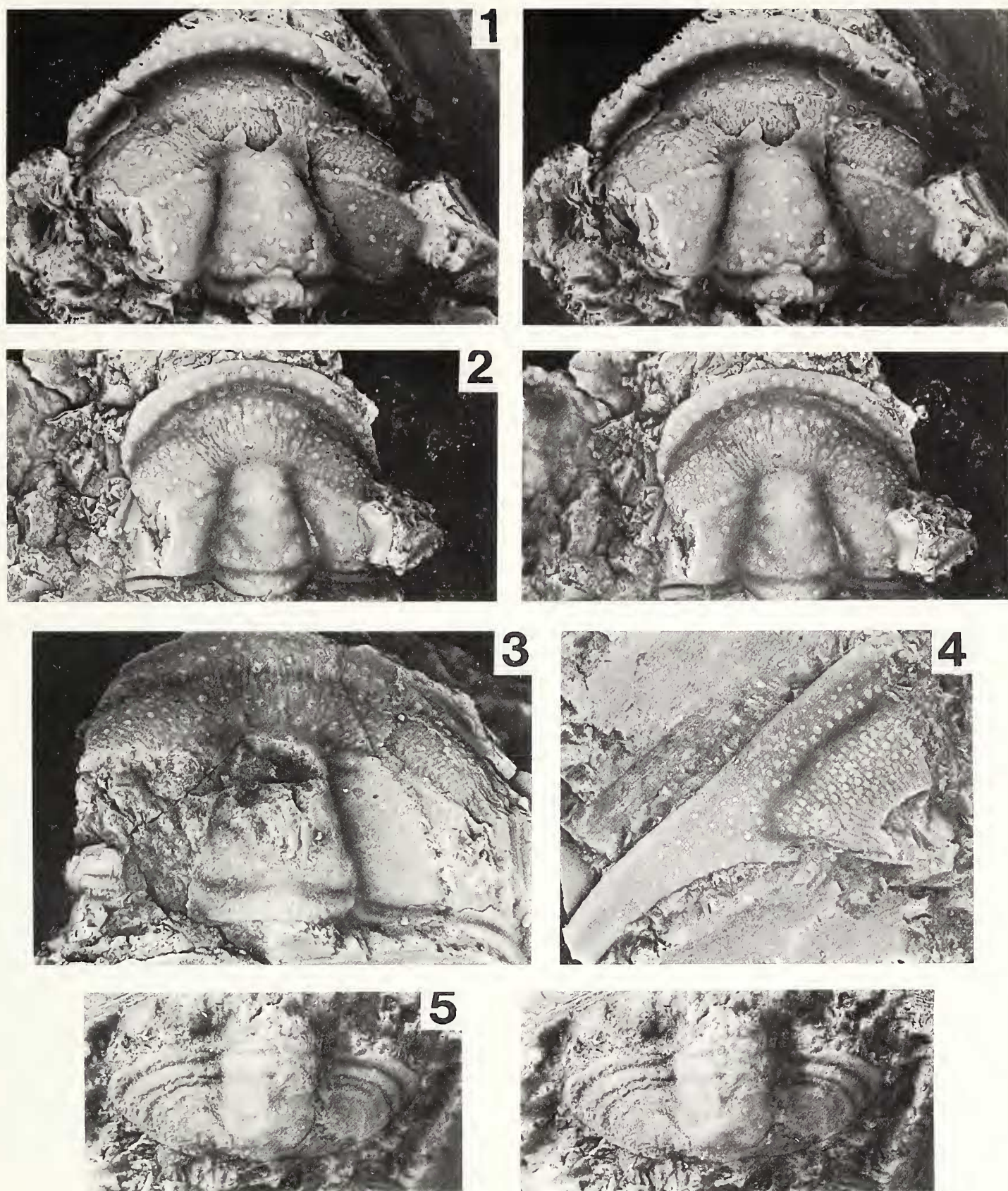


Figure 59. *Altiocculus concavus*, new genus and species. 1, Stereo pair of holotype cranidium (LACMIP 11908), LACMIP locality 15500, exfoliated, $\times 4.7$. 2, Stereo pair of small paratype cranidium (LACMIP 11909), LACMIP locality 15500, exfoliated, $\times 4.7$. 3, Large partial paratype cranidium (LACMIP 11914), LACMIP locality 15517, exfoliated, $\times 3.5$. 4, Paratype free cheek (LACMIP 11911), LACMIP locality 15500, exfoliated, $\times 4.5$. 5, Stereo pair of paratype pygidium (LACMIP 11912), LACMIP locality 15517, mostly exfoliated, $\times 12.5$.

erally, deep, deeper than axial furrows. Fixigena width, exclusive of palpebral lobe, 50–70% glabellar width, moderate to low convexity, upsloping, anterior area strongly downsloping. Palpebral lobe narrow, width 25–30% lobe length; moderate to large, length 35–45% glabellar length; anterior margin located adjacent to 30–40% glabellar length from anterior margin of frontal lobe; higher than adjacent cranidial features, upturned, furrow very shallow. Ocular ridge weak, thin, directed mod-

erately posterolaterally from glabella at 65–70° to axial trend. Posterior area of fixigena exsagittal width 15–25% glabellar length; length 35–40% glabella length; downsloping, sharply terminated. Posterior border high, strongly convex, uniform width; border furrow narrow, deep, curved posteriorly, wider laterally.

Librigena large, length 6.5 mm; moderately wide, width approximately 75% length without spine; lateral margin slightly curved; height approximately

50% width. Genal field gently convex, width approximately 50% librigenal width. Border width approximately 35% librigenal width; gently convex; lateral border furrow moderately shallow, shallowing posteriorly; posterior border furrow moderately shallow, shallowing laterally. Genal spine long, greater than length.

Hypostoma and thorax unknown.

Pygidium small, length 1.5 mm; subelliptical, length approximately 35% width; margin smooth, anterior margin slightly curved posteriorly; lateral margins evenly curved; posterior margin slightly flattened; low convexity (sag. and trans.), height approximately 20% width. Axis slightly tapered, axial mid-width approximately 90% axial anterior width, axial anterior width approximately 35% pygidial width; axial length approximately 90% pygidial length, no postaxial ridge; 3? axial rings, low convexity; terminal axial piece rounded; axial and axial ring furrows shallow to very shallow, uniform depth. Pleural regions well defined, transversely elongate, triangularly shaped; low convexity, slightly downsloping; anterior pleural furrow narrow, moderate depth, extends to margin, slightly curved posteriorly, recurved laterally; 2 additional pleural furrows, moderate depth to very shallow; interpleural furrows moderate depth to shallow, joining with pleural furrows at border; anterior pleural bands weakly convex; posterior pleural bands moderately convex. Border narrow, width approximately 10% pygidial length; very slightly convex, level; border furrow absent.

Exoskeleton thin; scattered coarse granules over entire cranidium and librigena, genal caeca on preglabellar field, anterior area of fixigena, genal area of librigenae; pygidium smooth on external and internal surfaces.

REMARKS. Cranidia of *Altiocculus concavus* can attain sizes larger than those given above. However, this larger size range was not given due to the typical breakage of the anterior border and anterior border furrow in larger specimens.

Altiocculus concavus is most similar to *A. catractense*, but differs in having a weaker median swelling that is not anteriorly placed and a well defined anterior border. *Altiocculus concavus* is also similar to *A. sinuatum* but differs in having a weaker medial swelling that is not anteriorly placed and a wider anterior border furrow. *Altiocculus concavus* differs from *A. americanum* in having a better defined, deeper, and wider (trans.) anterior border furrow and more divergent facial sutures anterior of the palpebral lobes.

ETYMOLOGY. Latin, *concavus* for the deeply concave anterior border furrow.

HOLOTYPE. Cranidium (LACMIP 11908) from the Swasey Limestone, Drum Mountains, Utah (LACMIP locality 15500).

PARATYPES. LACMIP 11909–11911 from LACMIP locality 15500; LACMIP 11912–11914 from LACMIP locality 15517.

OTHER MATERIAL. LACMIP locality 15495, 1 pygidium; LACMIP locality 15500, 4 cranidia; LACMIP locality 15517, 1 cranidium; LACMIP locality 15548, 1 pygidium; LACMIP locality 15580, 2 cranidia.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains and House Range, Utah. Trailer Limestone, Dugway Range. Pole Canyon Formation, Member E, Patterson Pass, Nevada.

Altiocculus cf. *A. harrisi*
(Robison, 1971)

Figure 60

REMARKS. A single fragmentary specimen resembling *Altiocculus harrisi* was found in the northern Egan Range. This moderate size specimen (7.1 mm in length) differs from *A. harrisi* in its more pronounced median swelling.

HYPOTYPE. LACMIP 11907 from LACMIP locality 15606.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Eldorado Formation, northern Egan Range, Nevada.

Genus *Pseudoalokistocare*, new genus

TYPE SPECIES. *Pseudoalokistocare swasii*, new species.

DIAGNOSIS. Small to moderate size *Altiocculinae* with cranidium with large (40–50% glabellar length), medially set, elevated palpebral lobes; moderately strong downsloping anterior area of fixigena and preglabellar field; strongly tapered glabella; elongated, narrow, median swelling either within or anterior of anterior border furrow; no deep pits in anterior border furrow; moderate width posterior area of fixigenae (35% glabellar length); fine granular ornamentation. Pygidium subelliptical, transversely elongate; tapered, narrow, level border; anterior pleural bands weakly convex; posterior pleural bands moderately to weakly convex.

REMARKS. *Pseudoalokistocare* can be distinguished from *Altiocculus* in its longer palpebral lobes, the medial swelling in or anterior of the anterior border furrow, wider posterior area of fixigenae, less tapered glabella, and fine granular ornamentation. *Pseudoalokistocare* differs from *Alokistocare* in having a rounded frontal lobe, slightly larger palpebral lobes (38–48% vs. 33–36% glabellar length, respectively), convex anterior border, and medial swelling not crossing from the preglabellar field onto the anterior border region (because of the taxonomic problems associated with the genus *Alokistocare*, these comparisons are based on the type species, *A. subcoronatum*, illustrated in Palmer (1954) and the type specimens in the USNM). *Pseudoalokistocare* differs from *Schopfaspis* in not possessing deep pits on either side of the medial swelling in the anterior border furrow



Figure 60. *Altiocculus* cf. *A. harrisi* (Robison). Stereo pair of partial cranidium (LACMIP hypotype 11907), LACMIP locality 15606, exfoliated, $\times 3.9$.

and in having a rounded frontal lobe and a more tapered glabella.

Pseudoalokistocare is placed in Altiocculinae because of its transversely elongate medial swelling occurring in the anterior border furrow region, anterior area of fixigena being relatively steeply downsloping, and shallow lateral glabellar furrows. Secondary preoccipital lobes may be present but very faint. Two species in this genus are recognized from the study area, *P. swasii* and *P. cf. P. paranotatum* (Rasetti, 1951). *Alokistocare paranotatum* is included in the genus based on its similarity in glabellar shape, shallow lateral glabellar furrows, downsloping frontal area, and the slight, elongate medial swelling on the anterior border. In *P. swasii*, it is unknown whether the true anterior border furrow passes anterior or posterior of the medial swelling. If *P. paranotatum* is correctly associated with the type species, then the true anterior border furrow is posterior of the medial swelling in *P. swasii* as it is in *P. paranotatum*.

A single pygidium associated with *P. cf. P. paranotatum* is assigned to the genus.

Pseudoalokistocare occurs in the *Elrathiella*?, *Ehmaniella*, and *Altiocculus* subzones of the *Ehmaniella* Biozone.

ETYMOLOGY. Greek, *pseudo* = lie, false, for false *Alokistocare*.

Pseudoalokistocare swasii, new species

Figure 61

DIAGNOSIS. *Pseudoalokistocare* with cranidium with median swelling in anterior border furrow; moderately curved, strongly tapered, flat to slightly convex, level anterior border.

DESCRIPTION. Cranidium small, length 4.0–5.1 mm; subpentagonal, length 70–75% width; moderate convexity (sag. and trans.), height 25–30% width; anterior margin moderately, evenly curved, anterior margin width approximately 70% cranidial width; posterior margin, excluding occipital ring, slightly backswept. Facial sutures slightly divergent from ends of palpebral lobes to anterior border furrow; strongly convergent across anterior

border; strongly divergent posterior of palpebral lobes. Glabella moderate length, length 60–65% and width 45–50% cranidial length; glabella width approximately 35% cranidial width; strongly tapered, width at anterior end 65–70% glabellar width; moderate convexity (sag. and trans.); anterior end moderately rounded, 3 lateral glabellar lobes, secondary preoccipital lobes(?). Axial furrow moderate depth, deeper medially, straight to very slightly concave; preglabellar furrow moderately shallow, narrow, moderately curved; lateral glabellar furrows very shallow to absent, F1 furrow bifurcated(?) directed posteriorly, F2 and F3 furrows directed slightly anteriorly. Occipital ring sagittal length 20–30% glabellar length, slightly elevated above glabella, low convexity; no occipital node or spine; furrow straight, shallow, slightly deeper laterally; posterior margin moderately curved. Frontal area length 35–40% cranidial length, equally divided. Preglabellar field slightly convex, moderately downsloping, length 45–50% frontal area length. Anterior border flat to slightly convex, level, strongly tapered laterally, evenly curved, sagittal length 50–55% frontal area length. Anterior border furrow evenly curved, moderately narrow, shallow, shallower than axial furrows; low relief, transversely elongate medial swelling. Fixigena width, exclusive of palpebral lobe, 60–70% glabellar width, low convexity, level, anterior area moderately downsloping. Palpebral lobe narrow, width 25–30% lobe length; long, length 38–48% glabellar length; anterior margin located adjacent to 15–30% glabellar length from anterior margin of frontal lobe; upturned, furrow moderately shallow. Ocular ridge moderate strength, thin, directed moderately posterolaterally from glabella at 70–75° to axial trend. Posterior area of fixigena exsagittal width approximately 35% glabellar length; length 65–70% glabella length; downsloping, sharply terminated. Posterior border high, strongly convex, uniform width; border furrow narrow, deep, straight, wider laterally.

Librigena, hypostoma, thorax, and pygidia unknown.

Exoskeleton thin; fine granules on cranidia on external and internal surfaces, genal caeca on pre-

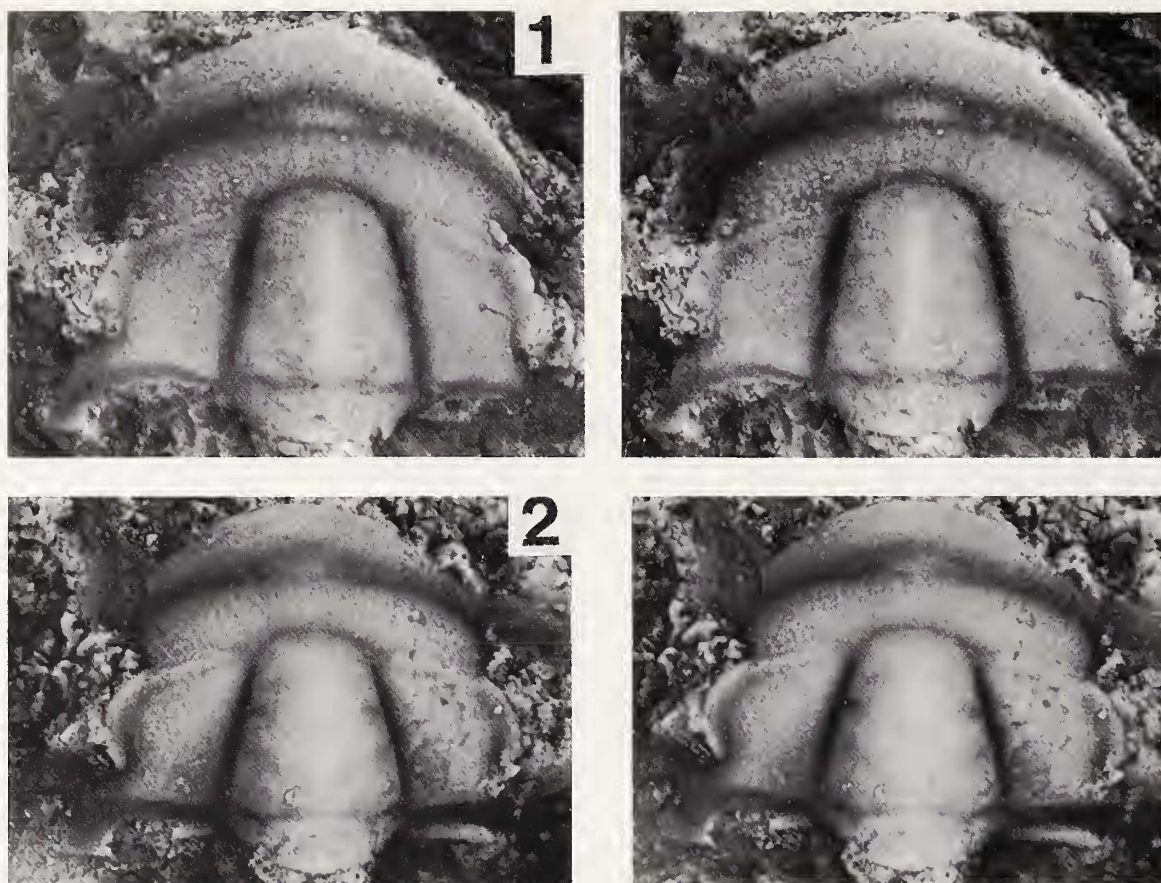


Figure 61. *Pseudoalokistocare swasii*, new genus and species, LACMIP locality 15490. 1, Stereo pair of holotype cranidium (LACMIP 11927), not exfoliated, $\times 9.2$. 2, Stereo pair of paratype cranidium (LACMIP 11926), not exfoliated, $\times 6.1$.

glabellar field, medial swelling, anterior area of fixigena.

REMARKS. *Pseudoalokistocare swasii* differs from *P. paranotatum* and *P. cf. P. paranotatum* in having a level, more tapered anterior border and a stronger medial swelling in the anterior border furrow.

ETYMOLOGY. Latinized, named after the Swasey Formation.

HOLOTYPE. Cranidium (LACMIP 11927) from the Swasey Limestone, Drum Mountains, Utah (LACMIP locality 15490).

PARATYPES. LACMIP 11925, 11926, 11928 from LACMIP locality 15490.

OTHER MATERIAL. LACMIP locality 15490, 6 cranidia; LACMIP locality 15491, 1 cranidium.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains, Utah.

Pseudoalokistocare
cf. *P. paranotatum*
(Rasetti, 1951)
Figure 62

REMARKS. Only a cranidium, librigena, and pygidium found together at one locality are assigned to *Pseudoalokistocare* cf. *P. paranotatum*. The cranidium is similar to *P. paranotatum* but differs in having weaker ocular ridges, medially deeper anterior border furrow, and less convergent facial sutures across the anterior border. The librigena is

nearly twice as long as the known cranidium but has a suture outline similar to that of the associated cranidium and is thus assigned to *P. cf. P. paranotatum*. The pygidium associated with the cranidium and librigena is more questionably assigned to the species. It is very similar to an *Ehmaniella* pygidium and may belong to a species of *Ehmaniella* not recognized at the locality. If the pygidium is correctly assigned, then this further indicates the *Altiocculinae* has close phylogenetic ties to the *Ehmaniellinae*.

Pseudoalokistocare cf. *P. paranotatum* differs from *P. swasii* in having a strongly tapered, level anterior border and a medial swelling on the anterior border.

HYPOTYPES. LACMIP 11922–11924 from LACMIP locality 15477.

OCCURRENCE. *Ehmaniella* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains, Utah.

Pseudoalokistocare?, sp. unidet.
Figure 63

REMARKS. Fragmentary cranidia resembling *Pseudoalokistocare* were found in the Dome Limestone. These specimens have a rounded frontal lobe and a very shallow, elongate medial swelling either in the anterior border furrow or on the anterior border. The anterior border is concave and upturned. If these fragments are correctly assigned to *Pseudoalokistocare*, then they represent the oldest occurrence of the genus.

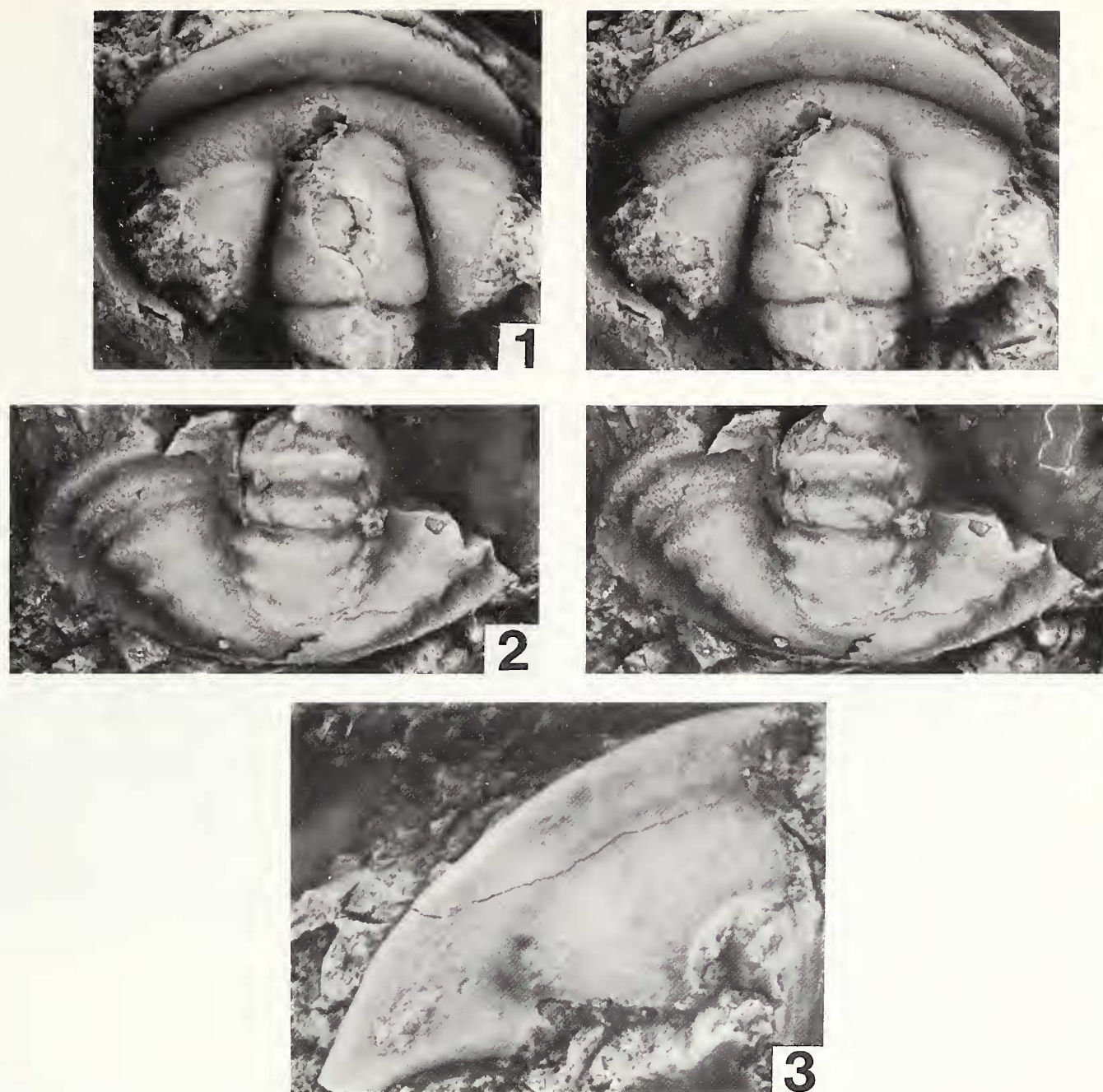


Figure 62. *Pseudoalokistocare* cf. *P. paranotatum* (Rasetti), LACMIP locality 15477. 1, Stereo pair of partial cranidium (LACMIP hypotype 11922), exfoliated, $\times 6.4$. 2, Stereo pair of pygidium (LACMIP hypotype 11923), mostly exfoliated, $\times 5.9$. 3, Large free cheek (LACMIP hypotype 11924), exfoliated, $\times 4.2$.

HYPOTYPE. KUMIP 204751 from RC locality 107.

OTHER MATERIAL. RC locality 107, cranidia fragments.

OCCURRENCE. *Elrathiella* Subzone, *Ehmaniella* Biozone. Dome Limestone, House Range, Utah.

Family Asaphiscidae Raymond, 1924

Genus *Glyphaspis* Poulsen, 1927

TYPE SPECIES. *Asaphiscus capella* Walcott, 1916.

DIAGNOSIS. Asaphiscidae with cranidia with short, tapered glabella, lateral glabellar furrows shallow to absent, frontal glabellar lobe rounded to bluntly rounded, shallow to moderate depth preglabellar and axial furrows, straight to slightly concave axial furrows, moderately strong ocular ridges, long palpebral lobes, posterior area of fixigena exsagittally narrower than occipital ring, fixigena moderately narrow, slightly convex preglabellar field and anterior area of fixigena, wide, moderately to strongly concave anterior border, anterior border furrow typically very faint. Pygidia large, subcircular, rounded anterolateral corners;

bellar field and anterior area of fixigena, wide, moderately to strongly concave anterior border, anterior border furrow typically very faint. Pygidia large, subcircular, rounded anterolateral corners;



Figure 63. *Pseudoalokistocare?* sp. Fragmentary specimen (KUMIP hypotype 204751), RC locality 107, partially exfoliated, $\times 5.0$.

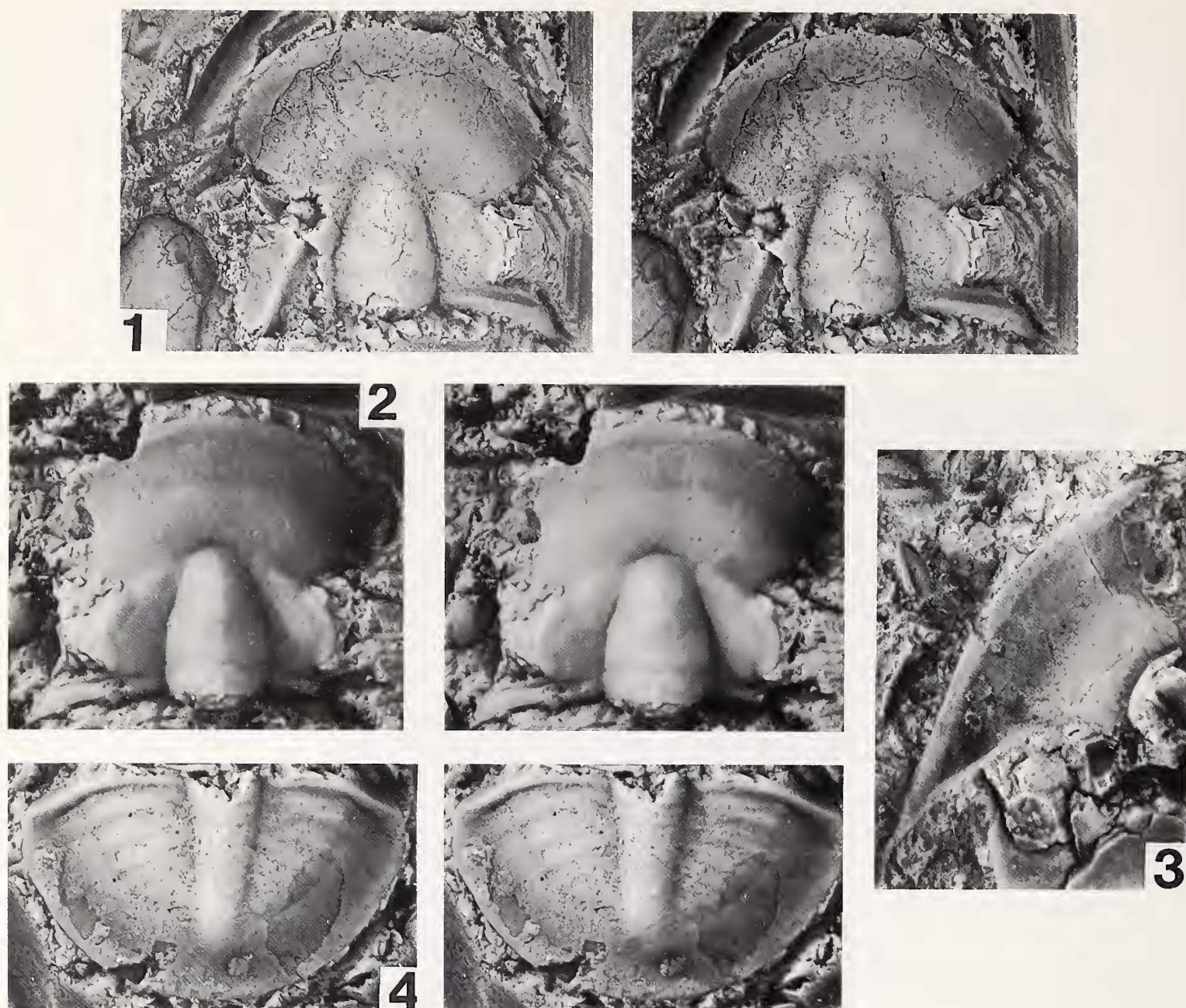


Figure 64. *Glyphaspis concavus*, new species. 1, Stereo pair of paratype cranium (LACMIP 11934), LACMIP locality 15548, exfoliated, $\times 3.4$. 2, Stereo pair of holotype cranium (LACMIP 11931), LACMIP locality 15543, exfoliated, $\times 3.9$. 3, Paratype free cheek (LACMIP 11933), LACMIP locality 15547, exfoliated, $\times 3.2$. 4, Stereo pair of paratype pygidium (LACMIP 11935), LACMIP locality 15548, partially exfoliated, $\times 3.7$.

multisegmented, well-defined, narrow axis reaching to border furrow or extending into border; pleural field well defined, pleural furrows shallow, extending onto border, interpleural furrows very shallow typically not extending onto border, low convexity; wide, slightly to moderately concave border; smooth, evenly rounded lateral and posterior margin.

REMARKS. Poulsen (1927) erected the genus, distinguished it from *Asaphiscus*, and provided a limited diagnosis; thus, a more complete diagnosis is presented here. *Glyphaspis* is easily distinguished from other genera from the *Ehmaniella* Biozone by its large pygidium with the pleural furrows extending onto the concave border and its cranium with a relatively small, smooth, tapered glabella and a broad, concave anterior border.

Glyphaspis concavus,
new species

Figure 64

Glyphaspis, n. sp. Sundberg, 1991:388, figs. 2.7, 2.8.

DIAGNOSIS. *Glyphaspis* with cranium with short, strongly tapered glabella from lobe L2 to anterior end, frontal lobe bluntly rounded; transversely wide anterior margin (80–95% cranial width); sagittally long frontal area (45–50% cranial length); concave, wide anterior border; very shallow anterior border furrow. Pygidium relatively transversely elongate, axis reaches margin of pleural field or extends onto border, faint postaxial ridge.

DESCRIPTION. Cranium moderate size, length 4.9–9.6 mm; hemicircular, length 70–85% width; moderate convexity (sag. and trans.), height 30–35% width; anterior margin moderately curved, anterior margin width 80–95% cranial width; posterior margin, excluding occipital ring, slightly backswept. Facial sutures strongly divergent from ends of palpebral lobes to anterior margin; anterolateral corners rounded; very strongly divergent posterior of palpebral lobes. Glabella short, length 50–55% and width 40–45% cranial length; glabella width 30–35% cranial width; very strongly tapered from lobe L2 to frontal lobe, width at anterior end of 55–65% glabellar width; moderately

low convexity (sag. and trans.); frontal lobe bluntly rounded, 3 lateral glabellar lobes. Axial furrows moderate to shallow depth, shallower anteriorly, straight to slightly convex; preglabellar furrow very shallow to shallow, slightly curved; lateral glabellar furrows very shallow to absent, F1 furrow directed posteriorly, F2 and F3 furrows directed laterally. Occipital ring sagittal length 20–25% glabellar length, not elevated above glabella, slightly convex; very small occipital node; furrow straight, shallow, slightly deeper laterally; posterior margin straight to slightly curved. Frontal area length 45–50% cranidial length, equally divided. Preglabellar field slightly convex, slightly downsloping, length 45–55% frontal area length. Anterior border slightly concave, level, not tapering laterally, evenly curved, sagittal length 45–55% frontal area length. Anterior border furrow evenly curved, very shallow to absent, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 45–60% glabellar width, very low convexity, upsloping. Palpebral lobe narrow, width 15–25% lobe length; long length, length 45–60% glabellar length; anterior margin located adjacent to 25–30% glabellar length from anterior margin of frontal lobe; furrow very shallow. Ocular ridge moderately strong, directed strongly posterolaterally from glabella at 60–65° to axial trend. Posterior area of fixigena exsagittal width 15–20% glabellar length; length 75–95% glabella length; backswept; sharply terminated. Posterior border moderately convex, slightly wider laterally; border furrow narrow, moderately shallow, straight, wider and deepens laterally.

Librigena moderate size, length 13.1 mm; moderately wide, width approximately 55% length without spine; lateral margin moderately, evenly curved. Genal field moderately convex, laterally concave, width approximately 80% librigenal width. Border width approximately 10% librigenal width; gently convex; lateral border furrow shallow, thin, uniform depth; posterior border furrow short, very shallow. Genal spine broad based, approximately 30% length.

Hypostoma and thorax unknown.

Pygidium moderate size to large, length 5.6–13.2 mm; hemicircular, transversely elongate, length 55–65% width; margin smooth, anterior margin slightly curved posteriorly; lateral and posterior margins evenly curved; moderately low convexity (sag. and trans.), height 20–25% width. Axis slightly tapered, axial mid-width 75–90% axial anterior width, axial anterior width 15–20% pygidial width; axial length 65–75% pygidial length, low, long postaxial ridge; 7(?) axial rings, low convexity; terminal axial piece rounded; axial furrow shallow; axial ring furrows shallow to very shallow. Pleural regions well defined, sagittally elongate, triangularly shaped; moderate convexity, downsloping; anterior pleural furrow narrow, shallow, extends nearly to margin, curved slightly posterior; 5–6 additional pleural furrows, shallow to very shallow, extending onto border; interpleural furrows very shallow to absent. Border wide, width 25–35% pygidial length, uni-

form width; concave, downsloping; border furrow shallow.

Exoskeleton very thin; all parts smooth on external and internal surfaces.

REMARKS. *Glyphaspis concavus* differs from all other species of *Glyphaspis* in its strongly tapered glabella anterior of the L1 glabellar lobe, rounded frontal lobe, and/or transverse or sagittal width of frontal area. The pygidium cannot be distinguished from the pygidia of either *G. robusta* Deiss, 1939, or *G. parkensis* Rasetti, 1951. *Glyphaspis concavus* is a common trilobite in the upper portion of the Swasey Limestone and stratigraphically equivalent units in the Great Basin.

ETYMOLOGY. Latin, *concavus* = hollow, arched, for the concave anterior border.

HOLOTYPE. Cranidium (LACMIP 11931) from the Trailer Limestone, Dugway Range, Utah (LACMIP locality 15543).

PARATYPES. LACMIP 11932 from LACMIP locality 15545; LACMIP 11933, 11934 from LACMIP locality 15547; LACMIP 11935–11943 from LACMIP locality 15548.

OTHER MATERIAL. LACMIP locality 15495, 28 cranidia, 14 pygidia, 5 librigenae; LACMIP locality 15496, 3 cranidia; LACMIP locality 15497, 4 cranidia, 1 pygidium; LACMIP locality 15499, 15 cranidia, 9 pygidia; LACMIP locality 15500, 2 cranidia; LACMIP locality 15516, 7 cranidia, 1 pygidium; LACMIP locality 15517, 9 cranidia; LACMIP locality 15536, 5 cranidia, 6 pygidia; LACMIP locality 15537, 7 cranidia, 4 pygidia; LACMIP locality 15538, 10 cranidia, 2 pygidia; LACMIP locality 15540, 9 cranidia, 9 pygidia; LACMIP locality 15541, 12 cranidia, 2 pygidia; LACMIP locality 15542, 2 cranidia, 4 pygidia; LACMIP locality 15543, 11 cranidia, 6 pygidia; LACMIP locality 15544, 22 cranidia, 13 pygidia; LACMIP locality 15545, 29 cranidia, 10 pygidia; LACMIP locality 15547, 26 cranidia; 19 pygidia; LACMIP locality 15548, 60 cranidia, 40 pygidia; LACMIP locality 15564, 9 cranidia; LACMIP locality 15565, 1 cranidium, 4 pygidia; LACMIP locality 15566, 1 pygidium; LACMIP locality 15568, 2 cranidia, 5 pygidia; LACMIP locality 15569, 2 cranidia, 6 pygidia.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains and House Range, Utah. Trailer Limestone, Dugway Range, Utah. Pole Canyon Limestone, Member E, Snake Range, Nevada.

Glyphaspis cf. *G. concavus*, new species

Figure 65

REMARKS. Cranidia of *Glyphaspis* cf. *G. concavus* are not well enough preserved to warrant the naming of a new species. These specimens are similar to *G. concavus* in their cranidial features except that the glabella is less tapered and the anterior border appears to be strongly upturned. The pygidium is also similar to the pygidium of *G. concavus*; however, the former differs in the larger specimens having a medial sulcus in the posterior margin.

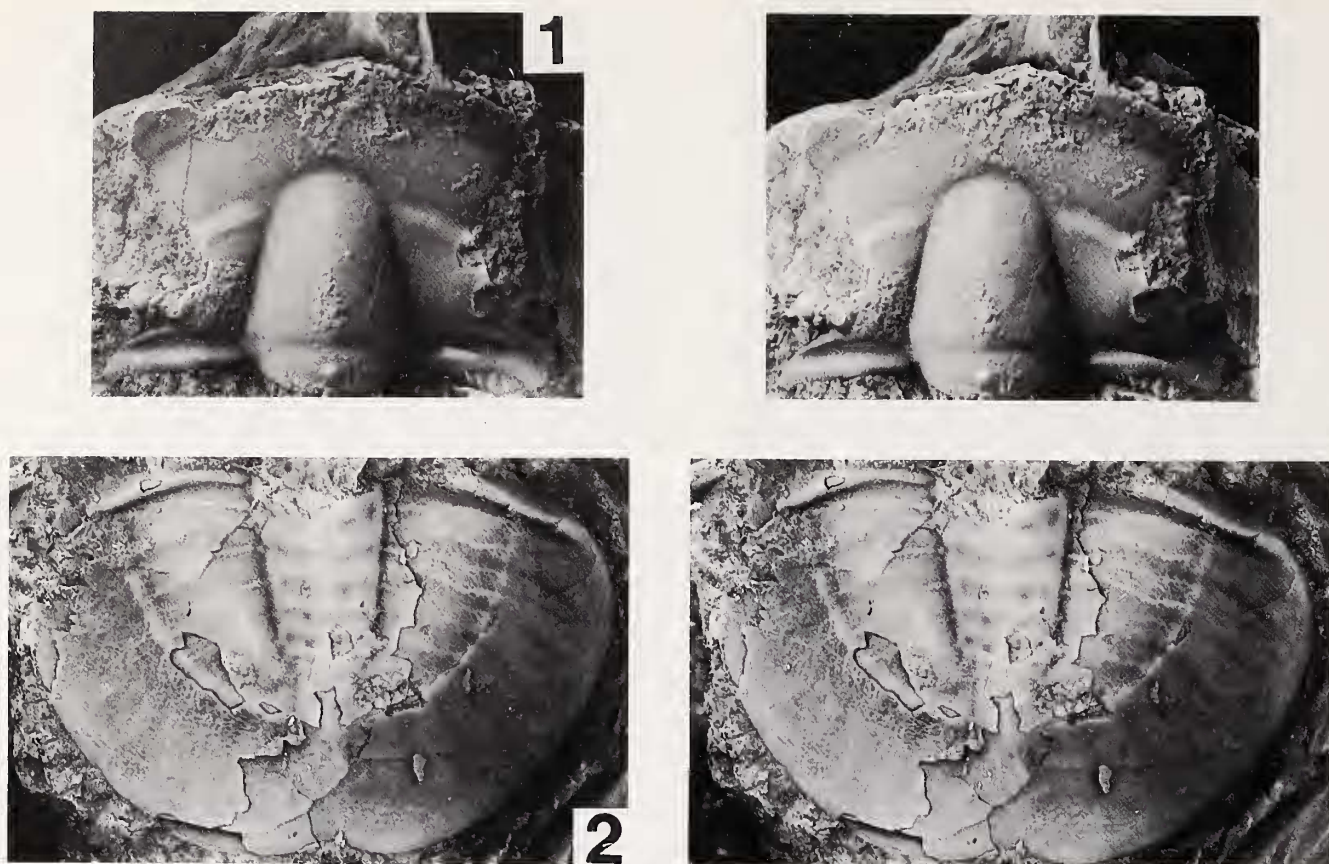


Figure 65. *Glyphaspis* cf. *G. concavus*, new species. 1, Stereo pair of partial cranidium (LACMIP hypotype 11929), LACMIP locality 15605, exfoliated, $\times 5.7$. 2, Stereo pair of large pygidium (LACMIP hypotype 11930), LACMIP locality 15602, partially exfoliated, $\times 1.8$.

HYPOTYPES. LACMIP 11929 from LACMIP locality 15605; LACMIP 11930 from LACMIP locality 15602.

OTHER MATERIAL. LACMIP locality 15600, 2 cranidia, 5 pygidia, 1 librigena; LACMIP locality 15601, 1 cranidium, 2 pygidia, 2 librigenae; LACMIP locality 15603, 1 pygidium; LACMIP locality 15604, 1 pygidium.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Eldorado Limestone, northern Egan Range, Nevada.

Family Uncertain

Genus *Bathyocos*, new genus

TYPE SPECIES. *Bathyocos housensis*, new species.

DIAGNOSIS. Small Ptychopariida with subtrapezoid cranidium with glabella elevated well above fixigena, moderately convex transversely; deep, short lateral glabellar furrows; rounded frontal lobe; convergent, deep axial furrows; downsloping, moderately wide fixigenae (60–65% glabellar width); narrow preglabellar field; convex, slightly curved, sagittally narrow, tapering anterior border; short palpebral lobes; weak, thin ocular ridges; short posterior area of fixigenae.

REMARKS. *Bathyocos* is most similar to *Spencella* in its elevated glabella, small palpebral lobes, convex anterior border, wide (exsag.) posterior area of fixigenae, and moderate divergent facial sutures posterior of the palpebral lobes. *Bathyocos* differs from *Spencella* in having deeper axial and lateral glabellar furrows, wider fixigenae, and sagittally

narrower, non-swollen, and/or less tapered anterior border. *Bathyocos* is monospecific and is not assigned to a supergeneric taxon despite its similarity to *Spencella*. The morphological similarity between the two genera may be due to their small size. The librigena, hypostoma, thorax, and pygidium of *Bathyocos* are unknown.

Bathyocos occurs in the *Altiocculus* Subzone of the *Ehmaniella* Biozone and the lowermost *Ptychagnostus gibbus* Biozone.

ETYMOLOGY. Greek, *bathys* = deep, *-okos* = furrow, for the deep axial and lateral glabellar furrows.

Bathyocos housensis, new species

Figure 66

DIAGNOSIS. Same as genus.

DESCRIPTION. Cranidium small, length 2.4–3.9 mm; subtrapezoid, length 60–65% width; moderate convexity (sag. and trans.), height approximately 35% width; anterior margin slightly curved, anterior margin width 55–65% cranidial width; posterior margin, excluding occipital ring, straight. Facial sutures moderately convergent from ends of palpebral lobes to anterior border; slightly convergent across anterior border; moderately divergent posterior of palpebral lobes. Glabella elongate, length 75–80% and width 50–60% cranidial length; glabella width 30–35% cranidial width; strongly tapered, width at anterior end 65–75% glabellar width; moderate convexity (sag. and trans.); frontal lobe moderately rounded, 3 lateral glabellar lobes. Axial furrows wide, deep, uniform depth, straight; preglab-



Figure 66. *Bathyocos housensis*, new genus and species. 1, Stereo pair of holotype cranidium (LACMIP 11947), LACMIP locality 15519, not exfoliated, $\times 13.0$. 2, Paratype cranidium (LACMIP 11948), LACMIP locality 15519, not exfoliated, $\times 10.6$. 3, Paratype cranidium (LACMIP 11944), LACMIP locality 15500, exfoliated, $\times 10.4$.

bellar furrow narrow, deep, moderately curved; lateral glabellar furrows short, deep to moderate depth, F1 furrow possibly bifurcated, directed posteriorly; F2 furrow directed very slightly posteriorly; F3 furrow directed laterally. Occipital ring sagittal length 20–25% glabellar length, slightly elevated above glabella, strongly convex; strong occipital node; furrow straight, deeper laterally, shallowing medially, deep to moderately deep, posterior margin moderately curved, flattened medially. Frontal area length 20–25% cranidial length, subequally divided. Preglabellar field moderately concave, downsloping, length 35–45% frontal area length. Anterior border strongly convex, level, slightly tapering laterally, evenly curved, sagittal length 55–65% frontal area length. Anterior border furrow evenly curved, narrow, moderate depth to deep, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 60–65% glabellar width, moderate convexity, level; anterior area of fixigena strongly downsloping. Palpebral lobe wide, width 40–50% lobe length; short, length 20–25% glabellar length; upturned; anterior margin located adjacent to 20–25% glabellar length from anterior margin of frontal lobe; furrow shallow depth. Ocular ridge moderately weak to weak, thin, directed slightly posterolaterally from glabella at 75–80° to axial trend. Posterior area of fixigena exsagittal width approximately 45% glabellar length; length 60–75% glabella length; bluntly terminated. Posterior border strongly convex, uniform width; border furrow narrow, deep, uniform depth, wider laterally, straight.

Librigena, hypostoma, thorax, and pygidium unknown.

Exoskeleton thin; fine granules on external and internal surfaces.

REMARKS. Same as genus.

ETYMOLOGY. Latinized, named after the House Range.

HOLOTYPE. Cranidium (LACMIP 11947) from the Wheeler Shale, House Range, Utah (LACMIP locality 15519).

PARATYPES. LACMIP 11944–11946 from LACMIP locality 15500; LACMIP 11948 from LACMIP locality 15519.

OTHER MATERIAL. LACMIP locality 15500, 3 cranidia; LACMIP locality 15519, 5 cranidia; LACMIP locality 15572, 2 cranidia.

OCCURRENCE. *Altioculus* Subzone, *Ehmaniella* Biozone and lowermost *Ptychagnostus gibbus* Biozone. Swasey Limestone, Drum Mountains, Utah. Wheeler Shale, House Range, Utah. Pole Canyon Limestone, Member E, Snake Range, Nevada.

Genus *Chanciaopsis*, new genus

TYPE SPECIES. *Chanciaopsis heteromorphos*, new species.

DIAGNOSIS. Large, micropygous Ptychopariida with subrectangular to subpentagonal cranidium with strongly to very strongly tapered glabella; secondary basal glabellar lobe weakly developed; gla-

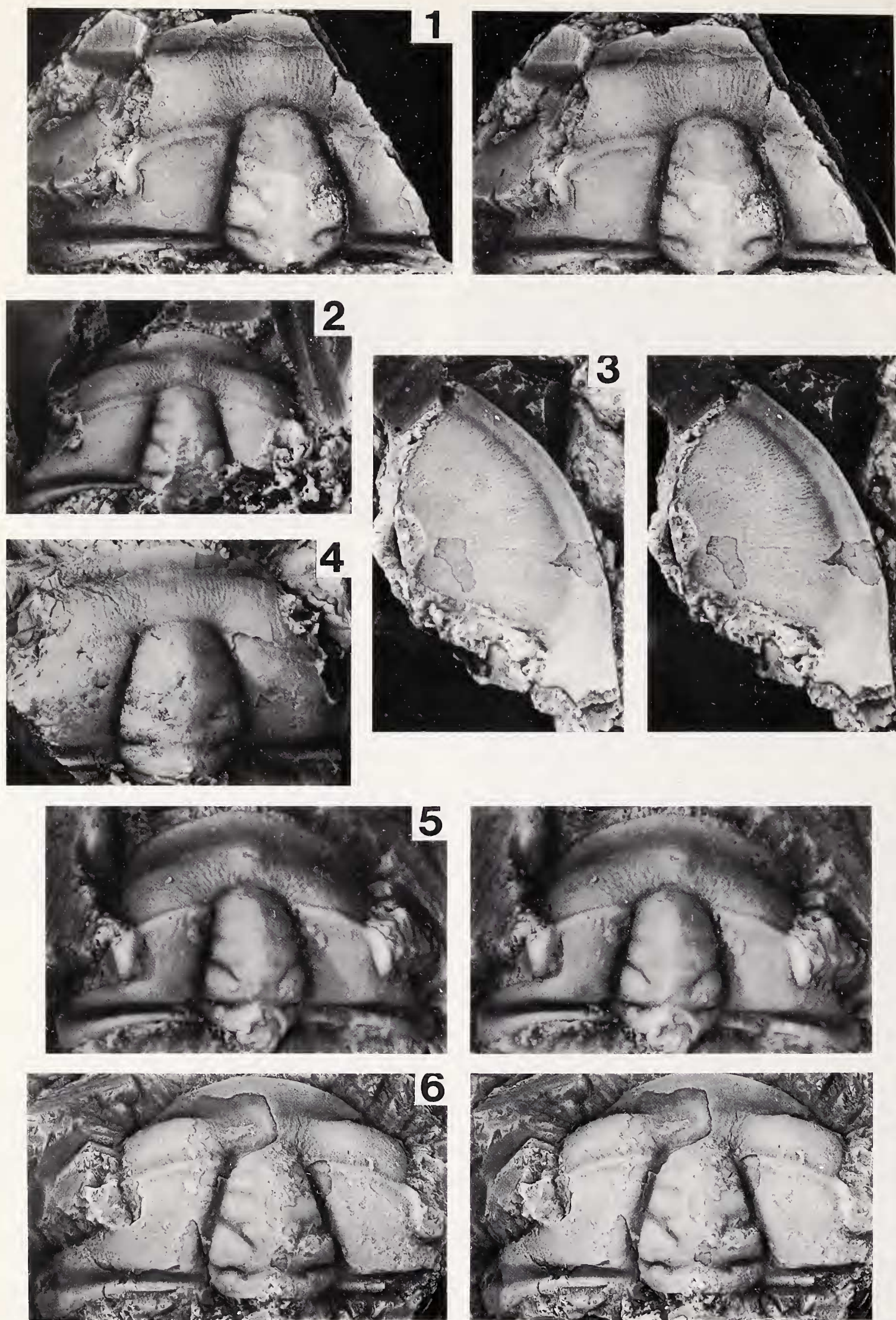


Figure 67. *Chanciaopsis heteromorphos*, new genus and species. 1, Stereo pair of holotype cranidium (LACMIP 11953), LACMIP locality 15544, partially exfoliated, $\times 3.4$. 2, Small paratype cranidium (LACMIP 11952), LACMIP locality 15543, exfoliated, $\times 4.8$. 3, Stereo pair of paratype free cheek (LACMIP 11954), LACMIP locality 15547, slightly exfoliated, $\times 2.8$. 4, Paratype cranidium (LACMIP 11949) with nearly effaced glabellar furrows, LACMIP locality

bella width approximately 25% cranial width; short to moderate length, medially set, non-elevated palpebral lobes; slightly to very strongly downsloping anterior area of fixigena and preglabellar field; median swelling, when present, posterior of anterior border furrow; moderately wide posterior area of fixigenae, rounded terminations; smooth or fine granules.

REMARKS. *Chanciaopsis* is a difficult genus to characterize because of the morphologic range displayed by the species *C. heteromorphos*, which spans a range that would be typically assigned to two different genera. Because of the variation of *C. heteromorphos* (specimens with and without a medial swelling—discussed below in the species description), it is deemed as the type species. The less morphologically variable species, *Chancia odarayensis* Rasetti, 1951, is also assigned to the genus. *Chancia palliseri* (Walcott, 1908b) is questionably assigned to the genus because of its sharply terminated posterior area of fixigenae and shallow lateral glabellar furrows. If *C. palliseri* is correctly assigned to *Chanciaopsis*, then this genus possess 20–23 thoracic segments and a pygidium similar to *Altiocculus*.

Chanciaopsis is most similar to *Chancia* Walcott, 1924. *Chancia* is a lower Middle Cambrian genus characterized by wide fixigenae, transversely long posterior area of fixigenae, sagittally wide frontal area, and well-defined glabella with shallow to moderate depth lateral glabellar furrows (Palmer and Halley, 1979). The glabella of *Chancia* is typically relatively short and strongly tapering with a bluntly rounded frontal lobe, moderate to very shallow glabellar furrows, and moderately deep, straight to slightly convex axial furrows. The glabellae of *C. ebdome* Walcott, 1924 (type species); *C. agusta* Resser, 1939a; and *C. evax* (Walcott, 1925) are strongly to very strongly tapered. Facial sutures of *Chancia* are typically divergent to nearly parallel from the palpebral lobes to the anterior border. Specimens of *C. latigena* Rasetti, 1951, and *C. granulosa* Rasetti, 1951, are distorted and it is difficult to judge cranial proportions.

Contrasting *Chanciaopsis* and *Chancia* is difficult because of the range of morphology displayed by *Chanciaopsis heteromorphos*. If comparisons are restricted to specimens of *Chanciaopsis heteromorphos* lacking a medial swelling and *C. odarayensis* and species of *Chancia*, then the two genera can be separated based on the former having a longer glabellar length (65–70% vs. 55–67% of cranial length), greater fixigenae width (64–74% vs. 50–62% glabellar length), slightly convergent facial sutures anterior of palpebral lobes, and gen-

erally deeper lateral glabellar furrows. The specimens of *Chanciaopsis heteromorphos* with a medial swelling differ from *Chancia* species in the presence of the medial swelling, longer glabellar lobe, deeper lateral glabellar furrows, and stronger downsloping of anterior area of fixigena and preglabellar field. These specimens have divergent anterior facial sutures and a wider anterior border, as does *Chancia*. Larger specimens (>10 mm) of *Chanciaopsis* have posterior area of fixigenae 110–120% glabella length, whereas *Chancia* has posterior area of fixigenae 80–100% glabella length. Ratios for *Chancia* are based on the illustrated specimens of *C. ebdome*, *C. agusta*, *C. evax*, and *C. vestita* (Resser, 1939a) in Resser (1939a, b), of which the first three species are compressed in shales, which would increase the lengths of the fixigenae and posterior area of fixigenae.

Chanciaopsis heteromorphos has a broad range of morphologies; one extreme morphology (Fig. 67.4) suggests that *Chanciaopsis* may be closely related to *Altiocculus*. This specimen has very shallow lateral glabellar furrows; relatively short, moderately strongly tapered, and broad glabella, convex axial furrows; and very faint secondary basal lobes. These features are very similar to larger specimens of *Altiocculus drumensis*. Furthermore, if *C. palliseri* is included in the genus, then *Chanciaopsis* also has a pygidium similar to *Altiocculus*. These similarities suggest that *Chanciaopsis* may belong in Altiocculinae.

Chanciaopsis occurs in the *Altiocculus* Subzone of the *Ehmaniella* Biozone.

ETYMOLOGY. Greek, *-opsis* = like, for the likeness to *Chancia*.

Chanciaopsis heteromorphos, new species

Figure 67

DIAGNOSIS. *Chanciaopsis* with two cranial types. Specimens without prominent medial swelling with convergent, concave facial suture anterior of palpebral lobes; flat, level anterior border, very slight median swelling in anterior border furrow; moderate to large palpebral lobes, moderately posterior directed ocular ridges; anterior area of fixigena and preglabellar field slightly downsloping to very strongly downsloping; and moderately narrow posterior area of fixigenae (30–40% glabellar length). Specimens with prominent medial swelling with divergent convex facial sutures anterior of palpebral lobes; flat, level anterior border relatively wide; moderate to large palpebral lobes, moderately posterior directed ocular ridges; anterior area of fixigena and preglabellar field moderately downsloping

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15517, partially exfoliated, ×4.1. 5, Stereo pair of small paratype cranium (LACMIP 11950), LACMIP locality 15541, exfoliated, ×7.8. 6, Stereo pair of larger paratype cranium (LACMIP 11951), LACMIP locality 15543, partially exfoliated, ×2.8.

to very strongly downsloping; and moderately narrow posterior area of fixigenae.

DESCRIPTION. Cranidium moderate size, length 4.2–12.1 mm; subpentagonal, length 50–55% width; low to strong sagittal and moderate transverse convexity, height 20–30% width; anterior margin slightly to moderately, evenly curved, anterior margin with 55–70% cranial width; posterior margin, excluding occipital ring, slightly backswept. Facial sutures slightly convergent and concave to slightly divergent and convex from ends of palpebral lobes to anterior border furrow; strongly convergent across border; strongly divergent posterior of palpebral lobes. Glabella moderately elongate, length 65–70% and width 50–60% cranial length; glabella width 25–35% cranial width; strongly to very strongly tapered, width at anterior end 60–70% glabellar width; moderate convexity (sag. and trans.); frontal lobe moderately rounded, 3 lateral glabellar lobes, very poorly developed secondary basal lobe. Axial furrows moderately deep to deep, deeper posteriorly, slightly convex in larger specimens, very slightly concave in smaller specimens; preglabellar furrow shallow to moderately deep, narrow, moderately curved; lateral glabellar furrows very shallow to deep, F1 furrow bifurcated, directed posteriorly, F2 furrow directed slightly posteriorly, F3 directed slightly anteriorly. Occipital ring sagittal length 20–25% glabellar length, slightly elevated above glabella, low convexity; small occipital node; furrow curved anteriorly, moderately deep laterally, shallow medially; posterior margin slightly curved to straight. Frontal area length 30–35% cranial length, subequally to unequally divided. Preglabellar field may possess median swelling, circular or subtriangular, moderately convex, area around swelling depressed; slightly to strongly downsloping, length 50–65% frontal area length. Anterior border flat, level, moderately tapered laterally, evenly curved, sagittal length 35–50% frontal area length. Anterior border furrow evenly curved, moderately narrow, shallow, shallower than axial furrows, very low transversely elongate medial swelling. Fixigena width, exclusive of palpebral lobe, 60–75% glabellar width, moderate convexity, upsloping, anterior area moderately to strongly downsloping. Palpebral lobe narrow to moderate width, width 25–40% lobe length; moderate length to long, length 30–45% glabellar length; anterior margin located adjacent to 20–30% glabellar length from anterior margin of frontal lobe; upturned, furrow shallow. Ocular ridge weak to moderate strength, moderately thin, directed moderately posterolaterally from glabella at 65–70° to axial trend. Posterior area of fixigena width 30–40% glabellar length; length 90–120% glabella length; downsloping and backswept laterally, roundly terminated. Posterior border high, strongly convex, wider laterally; border furrow narrow, deep, curved posteriorly, uniform width.

Librigena large, length 12.3 mm; wide, width approximately 55% length without spine; lateral mar-

gin moderately curved; height approximately 45% width. Genal field gently convex, width approximately 80% librigenal width. Border width approximately 20% librigenal width; gently convex; lateral border furrow shallow, uniform depth; posterior border furrow absent. Genal spine unknown.

Hypostoma, thorax, and pygidium unknown.

Exoskeleton thin; fine granules on external surface of cranidium, genal caeca on anterior area of fixigena, preglabellar field (not on median swelling), and librigenae on external and internal surfaces.

REMARKS. *Chanciaopsis heteromorphos* spans a morphological range typical of two genera. Specimens are grouped into two morphological types, one with a prominent median swelling and one without a prominent median swelling. However, the strong or very weak development of the median swelling appears to be the only consistent difference between the two groups. There is no other break between the two morphologies and the two types represent extremes in a continuum. Variable features include the sagittal width of the posterior area of fixigena, depth of lateral glabellar furrows and axial furrows, tapering of glabella, width of anterior margin, and degree of downsloping of the anterior area of the fixigena and preglabellar field. Typically, the specimens with a median swelling have a steeper downsloping of the anterior area of fixigena and preglabellar lobe, wider anterior margin, and divergent anterior facial sutures, but some specimens without a median swelling also show these characters. Both morphologies of the species commonly occur together at the same locality.

The specimens with a median swelling are unlike other *Chanciaopsis* species. Specimens without a median swelling are similar to *C. odorayensis* but differ in having larger palpebral lobes, concave anterior border, and moderately posterolaterally directed ocular ridges.

ETYMOLOGY. Latinized, named after the Swasey Limestone.

HOLOTYPE. Cranidium (LACMIP 11953) from the Trailer Limestone, Dugway Range, Utah (LACMIP locality 15544).

PARATYPES. LACMIP 11949 from LACMIP locality 15517; LACMIP 11950 from LACMIP locality 15541; LACMIP 11951, 11952 from LACMIP locality 15543; LACMIP 11954 from LACMIP locality 15547; LACMIP 11955–11957 from LACMIP locality 15548.

OTHER MATERIAL. LACMIP locality 15496, 3 cranidia; LACMIP locality 15500, 13 cranidia; LACMIP locality 15517, 8 cranidia; LACMIP locality 15541, 1 cranidium; LACMIP locality 15542, 1 cranidium; LACMIP locality 15543, 15 cranidia; LACMIP locality 15544, 2 cranidia; LACMIP locality 15545, 13 cranidia; LACMIP locality 15547, 2 cranidia; LACMIP locality 15548, 12 cranidia; LACMIP locality 15565, 1 cranidium; LACMIP locality 15568, 5 cranidia; LACMIP locality 15569, 6 cranidia; LACMIP locality 15570, 6 cranidia; LACMIP locality 15571, 1? cranidium; LACMIP locality 15572, 1 cranidium.

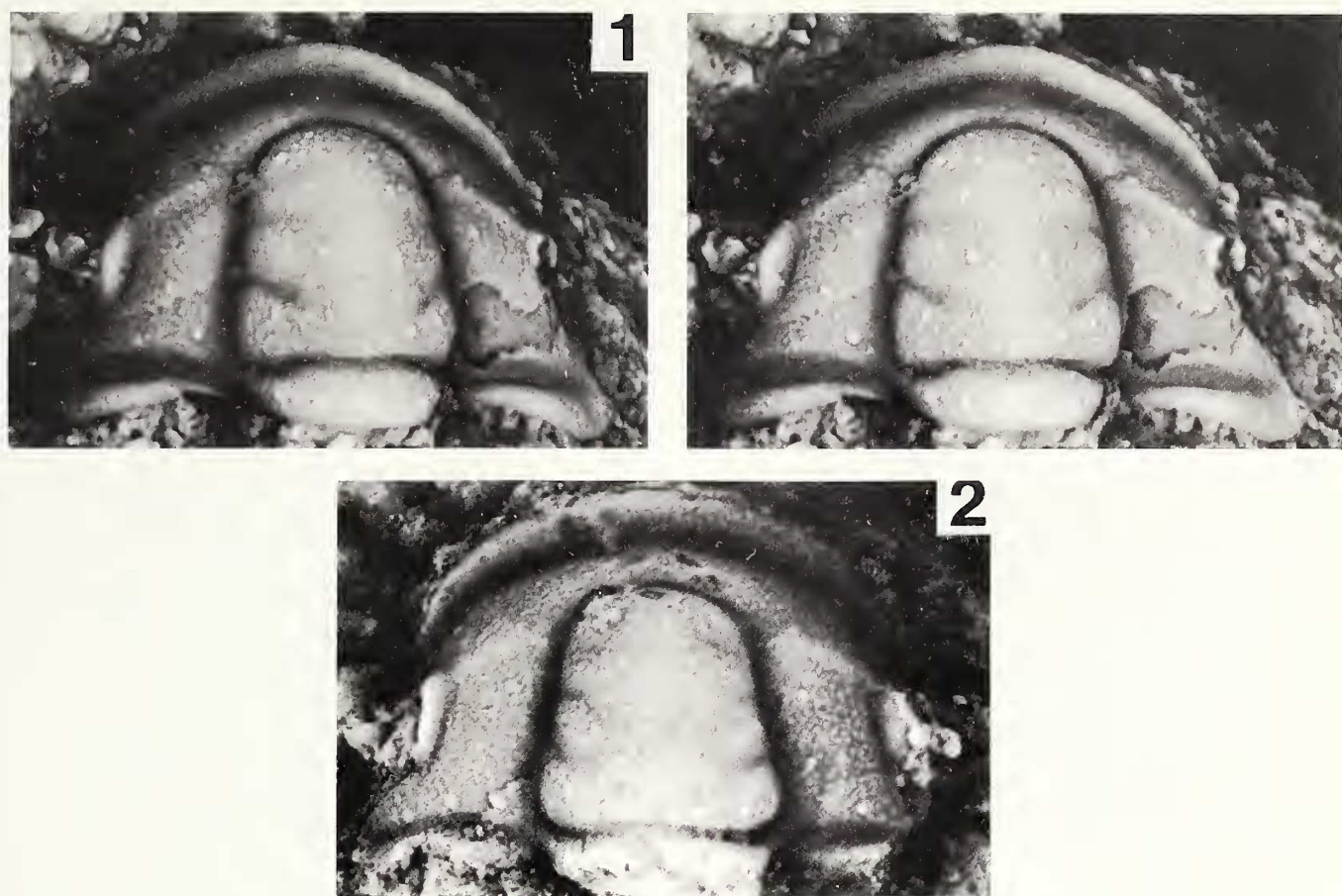


Figure 68. *Deltina limba*, new genus and species, LACMIP locality 15531. 1, Stereo pair of holotype cranidium (LACMIP 11965), slightly exfoliated, $\times 13.0$. 2, Paratype cranidium (LACMIP 11964), exfoliated, $\times 13.4$.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains and House Range, Utah. Trailer Limestone, Dugway Range, Utah. Pole Canyon Limestone, Member E, Snake Range, Nevada.

Genus *Deltina*, new genus

TYPE SPECIES. *Deltina limba*, new species.

DIAGNOSIS. Small Ptychopariida with subrectangular cranidium with a relatively large glabella elevated well above fixigena; moderately convex transversely; parallel to slightly convergent, moderate depth axial furrows; shallow to moderately shallow lateral glabellar furrows; rounded frontal lobe; downsloping, moderately narrow fixigenae; narrow or absent preglabellar field; convex, moderately to moderately strong curved, transversely wide, sagittally narrow, slightly tapering anterior border; moderate to short length palpebral lobes; moderate length posterior area of fixigenae.

REMARKS. *Deltina* is most similar to *Spencella* in its elevated, relatively large, subquadrate glabella. *Deltina* differs from *Spencella* in having a greater transverse width; a uniform width anterior border; rounded frontal lobe; and longer posterior area of fixigenae. *Deltina* differs from other Middle Cambrian ptychopariids in its relatively large, elevated glabella and in the character of the anterior border. The pygidium, thoracic segments, hypostoma, and librigenae are not known for *Deltina*.

Deltina occurs in the *Ehmaniella* Biozone.

ETYMOLOGY. Latinized, named for Delta, Utah, which is located near the type localities for both known species.

Deltina limba, new species

Figure 68

DIAGNOSIS. *Deltina* with cranidium with relatively wide preglabellar field (30–50% frontal area), moderate length palpebral lobes (30% glabellar length), anterior border curved moderately strong, granular ornamentation.

DESCRIPTION. Cranidium small, length 2.8–3.4 mm; rectangular, length 65–70% width; moderate convexity (sag. and trans.), height 30–35% width; anterior margin curved moderately strong, anterior margin width 65–80% cranidial width; posterior margin, excluding occipital ring, slightly backswept. Facial sutures parallel to slightly divergent from ends of palpebral lobes to anterior border; moderately convergent across anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 75–80% and width 55–65% cranidial length; glabella width approximately 40% cranidial width; strongly to moderately tapered, width at anterior end 70–80% glabellar width; moderate convexity (sag. and trans.); frontal lobe moderately rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, deeper posteriorly, slightly concave; preglabellar furrow moderate depth, moderately curved; lateral glabellar furrows shallow, F1 furrow bifurcated, directed posteriorly, F2

furrow directed slightly posteriorly, F3 furrow directed slightly posteriorly. Occipital ring sagittal length 20–25% glabellar length, not elevated above glabella, moderately convex; weak occipital node; furrow straight, deeper laterally, shallowing medially, moderately deep; posterior margin moderately curved, flattened medially. Frontal area length 20–25% cranial length, equally to subequally divided. Preglabellar field concave, downsloping, length 30–50% frontal area length. Anterior border strongly convex, level, slightly tapering laterally, evenly curved, sagittal length 50–70% frontal area length. Anterior border furrow evenly curved, broad, moderate depth, shallower or as deep as axial furrows. Fixigena width, exclusive of palpebral lobe, 25–45% glabellar width, low convexity, slightly downsloping; anterior area of fixigena moderately downsloping. Palpebral lobe wide, width approximately 40% lobe length; moderate length, length approximately 30% glabellar length; anterior margin located adjacent to 25–30% glabellar length from anterior margin of frontal lobe; furrow shallow depth. Ocular ridge moderately weak, directed moderately posterolaterally from glabella at 65–70° to axial trend. Posterior area of fixigena exsagittal width 30–40% glabellar length; length 60–65% glabella length; bluntly terminated. Posterior border strongly convex, slightly wider distally; border furrow narrow, deep, shallowing laterally, curved slightly posteriorly.

Librigena, hypostoma, thorax, and pygidium unknown.

Exoskeleton thin; fine granules with scattered coarse granules on external surface and internal mold.

REMARKS. *Deltina limba* differs from *D. angustigena*, new species, in having granular ornamentation, a sagittally wider preglabellar field, and strongly curved and transversely wide anterior border.

ETYMOLOGY. Latin, *limbus*, named for the strongly convex anterior border.

HOLOTYPE. Cranidium (LACMIP 11965) from the Trailer Limestone, Dugway Range, Utah (LACMIP locality 15531).

PARATYPES. LACMIP 11962, 11963 from LACMIP locality 15526; LACMIP 11964 from LACMIP locality 15531.

OTHER MATERIAL. LACMIP locality 15526, 1 cranidium; LACMIP locality 15529, 2 cranidia; LACMIP locality 15530, fragments; LACMIP locality 15491, 1 cranidium.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Trailer Limestone, Dugway Range, Utah. Swasey Limestone, Drum Mountains, Utah.

Deltina angustigena, new species

Figure 69

DIAGNOSIS. *Deltina* with cranidium with very narrow to narrow preglabellar field, moderate length

to long palpebral lobes (30–45% glabellar length), moderately curved anterior border, smooth exoskeleton.

DESCRIPTION. Cranidium small, length 2.5–4.7 mm; subrectangular, length 65–70% width; moderate convexity (sag. and trans.), height approximately 40% width; anterior margin moderately curved, anterior margin width approximately 65% cranial width; posterior margin, excluding occipital ring, slightly backswept. Facial sutures parallel to slightly divergent from ends of palpebral lobes to anterior border; moderately convergent across anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 80–85% and width 50–65% cranial length; glabella with 35–45% cranial width; strongly to slightly tapered, width at anterior end 70–90% glabellar width; moderate convexity (sag. and trans.); frontal lobe moderately rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, deeper posteriorly, slightly concave; preglabellar furrow shallow, moderately curved; lateral glabellar furrows shallow, F1 furrow bifurcated, directed slightly posterior, F2 and F3 furrows directed slightly anterior. Occipital ring sagittal length 20–25% glabellar length, not elevated above glabella, slightly convex; weak occipital node; furrow straight, deeper laterally, shallowing medially, moderate depth; posterior margin moderately curved, flatten medially. Frontal area length approximately 15% cranial length, subequally divided. Preglabellar field very narrow to narrow, slightly concave, downsloping, length 5–35% frontal area length. Anterior border strongly convex, level, slightly tapering laterally, evenly curved, sagittal length 65–95% frontal area length. Anterior border furrow evenly curved, broad, moderate depth, shallower or as deep as axial furrows. Fixigena width, exclusive of palpebral lobe, 30–50% glabellar width, low convexity, slightly downsloping; anterior area of fixigena moderately downsloping. Palpebral lobe narrow, width 25–30% lobe length; moderate length to long, length 30–45% glabellar length; anterior margin located adjacent to 30–35% glabellar length from anterior margin of frontal lobe; furrow moderate depth. Ocular ridge moderate to moderately weak, directed very strongly posterolaterally from glabella at 50–55° to axial trend. Posterior area of fixigena exsagittal width approximately 25% glabellar length; length 45–50% glabella length; bluntly terminated. Posterior border strongly convex, slightly wider distally; border furrow narrow, deep, shallowing laterally, curved slightly posteriorly.

Librigena, hypostoma, thorax, and pygidium unknown.

Exoskeleton thin; smooth on external and internal surfaces.

REMARKS. *Deltina angustigena* differs from *D. limba* in having a smooth exoskeleton, a sagittally narrower preglabellar field, narrower fixigena, and less strongly curved and narrower anterior border. *Deltina angustigena* differs from *Spencella? buttsi*

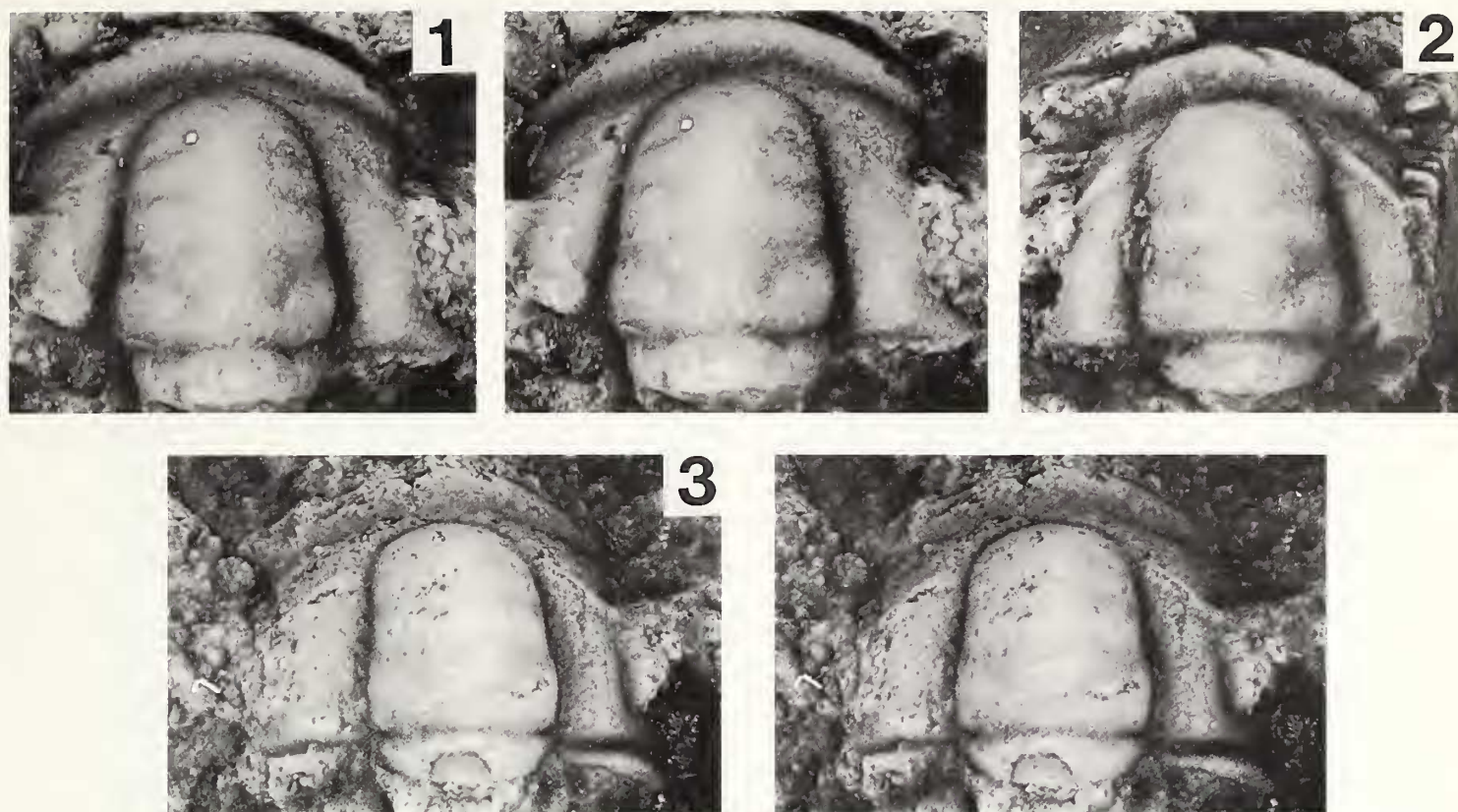


Figure 69. *Deltina angustigena*, new genus and species. RC locality 374. 1, Stereo pair of holotype cranidium (KUMIP 204728), mostly exfoliated, $\times 7.5$. 2, Partial paratype cranidium (KUMIP 204729), exfoliated, $\times 13.1$. 3, Stereo pair of paratype cranidium (KUMIP 204727), exfoliated, $\times 9.0$.

(Resser, 1938b), which with it occurs, in having narrower fixigenae, rounded frontal lobe, and a non-swollen, non-tapered anterior border.

ETYMOLOGY. Latin, *angustus* = narrow, *gena* = cheek, for its relatively narrow fixigenae.

HOLOTYPE. Cranidium (KUMIP 204728) from the Dome Limestone, House Range, Utah (RC locality 374).

PARATYPES. KUMIP 204726 from RC locality 211; KUMIP 204727, 204729 from RC locality 374.

OTHER MATERIAL. RC locality 211, 13 cranidia; RC locality 374, 17 cranidia; LACMIP locality 15462, 4 cranidia; LACMIP locality 15503, 8 cranidia.

OCCURRENCE. *Proehmaniella* Subzone, *Ehmaniella* Biozone. Dome Limestone, House Range and Drum Mountain, Utah.

Genus *Elrathina* Resser, 1937

TYPE SPECIES. *Conocephalites cordillerae* Rominger, 1887.

DIAGNOSIS. Small, micropygous Ptychopariida with subrectangular cranidium with convergent facial sutures anterior of the palpebral lobes, glabella elevated above fixigena; parallel to slightly convergent, moderate depth axial furrows; shallow to effaced lateral glabellar furrows; strongly rounded frontal lobe; slightly downsloping, moderately wide fixigenae; narrow preglabellar field; convex, slightly to moderately curved, sagittally narrow, tapering anterior border; short palpebral lobes anterior of glabellar midlength. Free cheeks lack significant development of genal spines. Triangular pygidium.

REMARKS. The diagnosis is a combination from Deiss (1939) and Palmer (in Palmer and Halley, 1979).

Elrathina wheelera, new species

Figure 70

Elrathina, n. sp. Sundberg, 1991:388, fig. 2.6.

DIAGNOSIS. *Elrathina* with cranidium with transversely wide anterior border, transversely wide fixigenae (70–80% glabellar width), moderate size recurved occipital spine.

DESCRIPTION. Cranidium small to moderate size, length 3.1–6.2 mm; subtrapezoidal, length 60–70% width; moderately low convexity (sag. and trans.), height 25–40% width; anterior margin moderately curved, anterior margin width 60–70% cranidial width; posterior margin, excluding occipital ring, straight. Facial sutures moderately convergent from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of border; moderately divergent posterior of palpebral lobes. Glabella moderately elongate, length 70–75% and width 45–55% cranidial length; glabellar width 30–35% cranidial width; slightly tapered, width at anterior end 85–90% glabellar width; moderate to moderately low convexity (sag. and trans.); frontal lobe bluntly rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, slightly concave; preglabellar furrow moderate depth, slightly curved; lateral glabellar furrows very shallow, F1 furrow bifurcated, directed posteriorly, F2 and F3 furrows

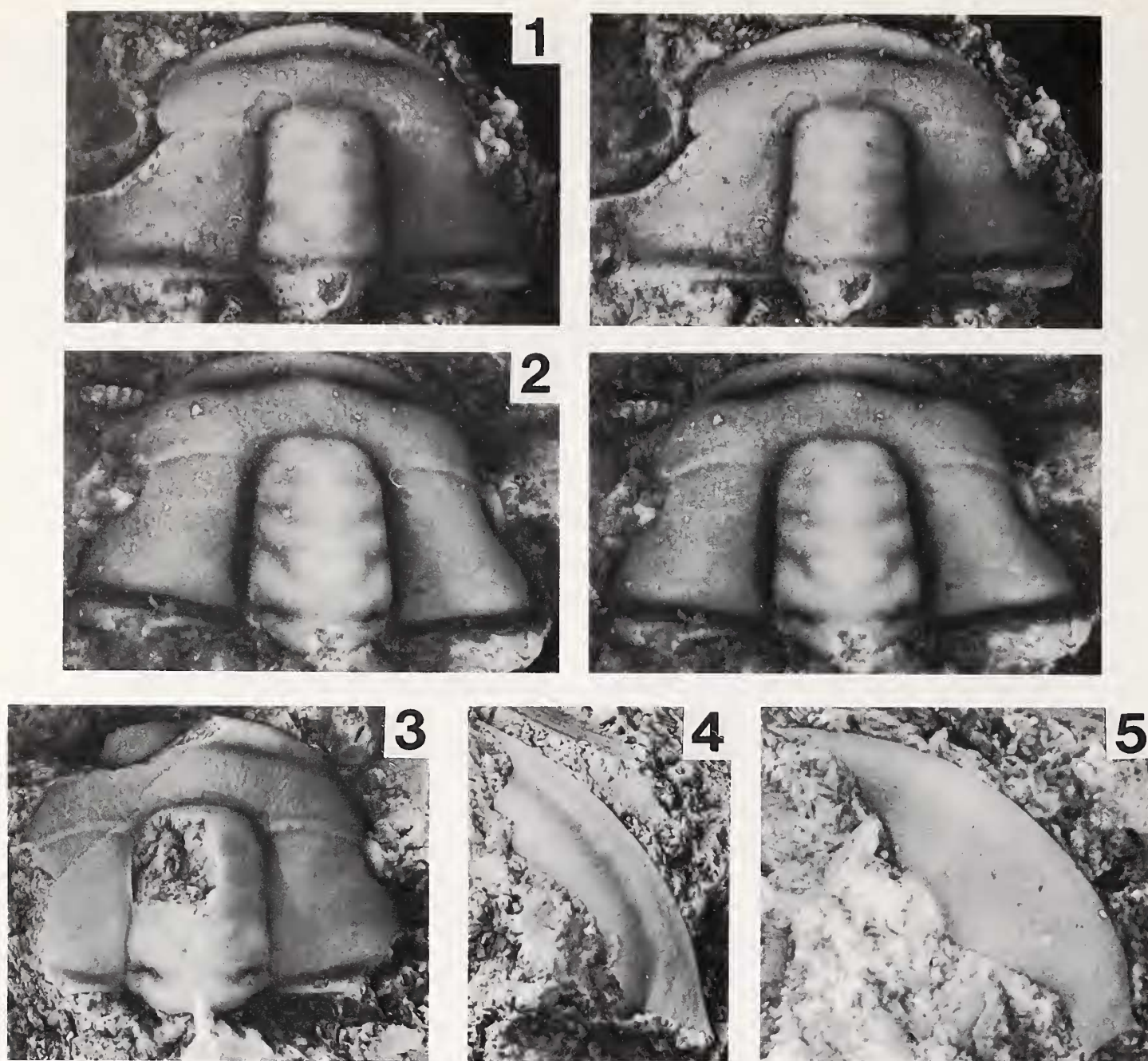


Figure 70. *Elrathina wheeleri*, new species. 1, Stereo pair of holotype cranidium (LACMIP 11968), LACMIP locality 15519, partially exfoliated, $\times 6.8$. 2, Stereo pair of paratype cranidium (LACMIP 11966), LACMIP locality 15518, $\times 7.9$. 3, Larger paratype cranidium (LACMIP 11970) showing occipital spine, LACMIP locality 15519, partially exfoliated, $\times 5.3$. 4, Larger paratype free cheek (LACMIP 11972), LACMIP locality 15519, exfoliated, $\times 4.6$. 5, Smaller paratype free cheek (LACMIP 11973), LACMIP locality 15519, exfoliated, $\times 11.6$.

directed laterally. Occipital ring sagittal length 20–25% glabellar length, slightly convex; moderate length, recurved occipital spine; furrow straight, deep pits laterally, shallow medial; posterior margin slightly curved to flattened. Frontal area length 25–30% cranidial length, subequally divided. Preglabellar field flat to slightly concave, slightly down-sloping, length 60–70% frontal area length. Anterior border strongly convex, upsloping, tapering laterally, evenly curved, sagittal length 30–40% frontal area length. Anterior border furrow evenly curved, moderate depth, shallowing medially and laterally, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 70–80% glabellar width, low convexity, very slightly down-sloping. Palpebral lobe narrow to moderate width, width 25–35% lobe length; short, length 20–25% glabellar length; anterior margin located adjacent to 10–20% glabellar length from anterior margin of frontal lobe; furrow moderate depth. Ocular

ridge moderately weak, larger specimens have double ridges, directed slightly posterolaterally from glabella at 80–85° to axial trend. Posterior area of fixigena exsagittal width 50–75% glabellar length; length 70–75% glabella length; sharply terminated. Posterior border moderately convex, distally wider; border furrow narrow, distally wider, deep to moderate depth, straight.

Librigena small to moderate size, length 4.6 mm; narrow, width approximately 35% length without spine; lateral margin gently curved; moderate convexity, height approximately 40% width. Genal field level to moderately convex, width approximately 55% librigenal width. Border width approximately 35% librigenal width; slightly convex to flat; level to downsloping; lateral border furrow very shallow; posterior border furrow absent to very short, very shallow. Genal spine very short, approximately 5% librigenal length.

Hypostoma, thorax, and pygidium unknown.



Figure 71. *Spencella? buttsi* (Resser). 1, Stereo pair of cranidium (KUMIP hypotype 204757), locality RC 211, partially exfoliated, $\times 14.4$. 2, Stereo pair of partial cranidium (KUMIP hypotype 204756), RC locality 211, exfoliated, $\times 12.7$.

Exoskeleton very thin; genal caeca on anterior area of fixigena and preglabellar field of cranidia and genal area of larger librigenae, some glabella with fine granules, otherwise smooth on external and internal surfaces.

REMARKS. *Elrathina wheelera* is most similar to *E. erecta* Deiss, 1939, in its parallel-sided glabella but differs in having an occipital spine, wider fixigenae, and a transversely wider, slightly curved anterior border. *Elrathina wheelera* differs from other species of *Elrathina* in its wider anterior margin and fixigena.

Elrathina wheelera occurs in the uppermost 0.5 m of the Swasey Limestone and overlying 20 cm of black, agnostoid-rich mudstones, which are here considered the Wheeler Shale.

ETYMOLOGY. Latinized, named after the Wheeler Shale.

HOLOTYPE. Cranidium (LACMIP 11968) from the Wheeler Shale, House Range, Utah (LACMIP locality 15519).

PARATYPES. LACMIP 11966, 11967 from LACMIP locality 15518; LACMIP 11959, 11969–11971, 11973 from LACMIP locality 15519.

OTHER MATERIAL. LACMIP locality 15517, 1 cranidium; LACMIP locality 15518, 11 cranidia; LACMIP locality 15519, 27 cranidia; LACMIP locality 15563, 3 cranidia; LACMIP locality 15572, 3 cranidia.

OCCURRENCE. *Altioculus* Subzone, *Ehmaniella* Biozone and lowermost *Ptychagnostus gibbus* Biozone. Swasey Limestone and Wheeler Shale, House Range, Utah. Member E, Pole Canyon Lime-

stone, and Lincoln Peak Shale, Snake Range, Nevada.

Genus *Spencella* Rasetti, 1963

TYPE SPECIES. *Spencella montanensis* Rasetti, 1963.

DIAGNOSIS. Small, micropygous Ptychopariida with subrectangular cranidium with glabella elevated well above fixigena; slightly convergent, moderate depth axial furrows; shallow to effaced lateral glabellar furrows; bluntly rounded from lateral lobe; downsloping, moderately narrow to fixigenae; narrow or absent preglabellar field; convex, moderately curved, sagittally narrow, strongly tapering, medially swollen anterior border; short length palpebral lobes; short (trans.) posterior area of fixigenae. Librigenae narrow, rounded at genal angle. Pygidium small, alate, elevated axis, 1–2 shallow pleural furrow pairs, poorly defined border.

REMARKS. The diagnosis is based on the description of Rasetti (1963). The species reported here are questionably assigned to *Spencella* because there are no associated librigenae and pygidia, both of which are necessary to separate *Spencella* from *Spencia* Resser, 1939a (Rasetti, 1963:591).

Spencella? buttsi (Resser, 1938a)

Figure 71

Solenopleurella buttsi Resser, 1938a:99, pl. 6, figs. 24, 25; Shimer and Shrock, 1944:pl. 255, fig. 22. *Spencella buttsi* (Resser), Rasetti, 1963:591.

DIAGNOSIS. *Spencella?* with cranidium with bluntly rounded glabella; convex axial furrows; moderately dorsally arched anterior border, 65–70% of frontal area, medial swelling absent or poorly developed; moderately high glabellar convexity (sag. and trans.); and exoskeleton smooth.

DESCRIPTION. Cranidium small, length 2.3–3.1 mm; rectangular, length 60–80% width; moderate convexity (sag. and trans.), height 30–40% width; anterior margin moderately curved, anterior margin width 50–80% cranial width; posterior margin, excluding occipital ring, straight. Facial sutures slightly convergent from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of anterior border; moderately divergent posterior of palpebral lobes. Glabella elongate, length 75–80% and width 60–75% cranial length; glabella width 40–50% cranial width; moderately to slightly tapered, width at anterior end 75–90% glabellar width; high convexity (sag. and trans.); frontal lobe flattened to bluntly rounded, 3 lateral glabellar lobes. Axial furrows moderate depth, slightly concave; preglabellar furrow moderate depth, straight to slightly curved; lateral glabellar furrows shallow to moderate depth, F1 furrow directed posteriorly, F2 and F3 furrows directed slightly posteriorly. Occipital ring sagittal length 20–25% glabellar length, slightly lower than glabella, slightly convex; occipital node absent(?); furrow straight, deep pits laterally, shallowing medially, moderate depth; posterior margin curved. Frontal area length 20–25% cranial length, subequally divided. Preglabellar field flat to slightly concave, slightly downsloping, length 25–40% frontal area length. Anterior border strongly convex, slightly upsloping, slightly to not swollen medially, tapering laterally, evenly curved, sagittal length 60–75% frontal area length. Anterior border furrow evenly curved, moderate depth shallowing medially, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 40–50% glabellar width, low convexity, very slightly downsloping. Palpebral lobe wide, width 40–45% lobe length; moderate length, length 30–40% glabellar length; anterior margin located adjacent to 15–25% glabellar length from anterior margin of frontal lobe; furrow moderate depth. Ocular ridge moderate to moderately weak, directed moderately posterolaterally from glabella at 70–75° to axial trend. Posterior area of fixigena exsagittal width 30–35% glabellar length; length 50–65% glabella length; bluntly terminated. Posterior border strongly to moderately convex, distally wider; border furrow narrow to moderately wide, deep to shallow, straight.

Librigena, hypostoma, thorax, and pygidium unknown.

Exoskeleton thin; smooth on external and internal surfaces.

REMARKS. Rasetti (1963) assigned *Solenopleurella buttsi* to *Spencella*, although neither the li-

brigena nor the pygidium that are needed to place the species in the genus are known. For this reason, this species is questionably assigned to *Spencella* here. *Spencella? buttsi* differs from other species of *Spencella* illustrated by Rasetti (1963) and Palmer (1968) in its narrow anterior border, absent or very slight medial inbending of anterior border furrow, and/or bluntly rounded glabella. *Spencella? buttsi* from the Great Basin does not differ significantly from the Appalachian specimens figured by Resser (1938a). *Spencella minori* (Resser, 1938a) may be conspecific with *S.? buttsi*, but the illustrations of Resser are inadequate for the comparison of the two species.

HYPOTYPES. KUMIP 204756, 204757 from RC locality 211.

OTHER MATERIAL. RC locality 211, 12 cranidia; RC locality 374, 20 cranidia; LACMIP locality 15462, 4 cranidia; LACMIP locality 15503, 8 cranidia.

OCCURRENCE. *Proehmaniella* Subzone, *Ehmaniella* Biozone. Dome Limestone, House Range and Drum Mountains, Utah.

Spencella? utahensa, new species

Figure 72

DIAGNOSIS. *Spencella?* with cranidium with bluntly rounded to rounded frontal lobe; straight to convex axial furrows; moderately to strongly, dorsally arched anterior border, 60–95% of frontal area, medial swelling strong; moderately high glabellar convexity (sag. and trans.); and fine granular ornamentation.

DESCRIPTION. Cranidium small, length 2.8–3.5 mm; subtrapezoidal, length 65–95% width; moderate convexity (sag. and trans.), height 30–45% width; anterior margin moderately curved, anterior margin width 55–80% cranial width; posterior margin, excluding occipital ring, straight. Facial sutures slightly convergent to parallel from ends of palpebral lobes to middle of anterior border; strongly convergent across anterior half of anterior border; moderately divergent posterior of palpebral lobes. Glabella elongate, length 75–85% and width 55–65% cranial length; glabella width 35–50% cranial width; strongly tapered, width at anterior end 70–75% glabellar width; high convexity (sag. and trans.); frontal lobe flattened to bluntly rounded, 3 lateral glabellar lobes. Axial furrows moderate depth to deep, slightly convex to straight; preglabellar furrow moderate depth, slightly curved; lateral glabellar furrows shallow to moderate depth, F1 furrow bifurcated, directed posteriorly, F2 and F3 furrows directed slightly posteriorly to laterally. Occipital ring sagittal length 20–25% glabellar length, slightly lower than glabella, strongly convex; occipital node to short spine; furrow straight, deeper laterally, moderate depth; posterior margin moderately curved. Frontal area length 15–25% cranial length, unequally divided. Preglabellar field

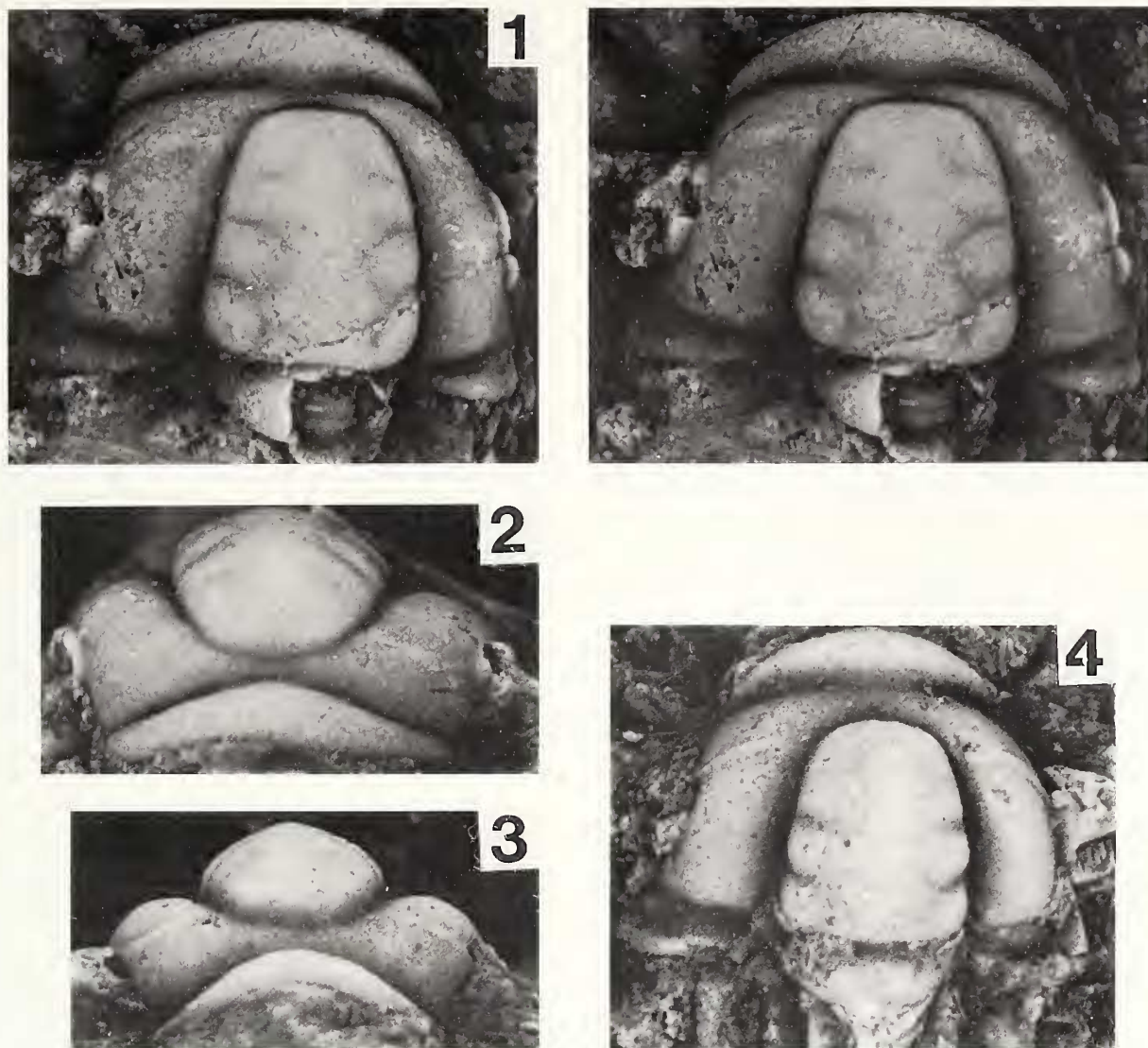


Figure 72. *Spencella? utahensa*, new species. 1, 2, Stereo pair and anterior view of holotype cranidium (LACMIP 11975), LACMIP locality 15536, exfoliated, $\times 11.6$. 3, 4, Paratype cranidium (LACMIP 11978), LACMIP locality 15580, exfoliated, $\times 12.8$.

slightly convex, downsloping, length 5–40% frontal area length. Anterior border strongly convex, level, swollen medially, strongly tapering laterally, evenly curved, moderately to strongly arched dorsally, sagittal length 60–95% frontal area length. Anterior border furrow evenly curved, moderate depth to deep, uniform depth to shallowing medially, as deep as axial furrows. Fixigena width, exclusive of palpebral lobe, 40–50% glabella width, weak to strong convexity, slightly downsloping. Palpebral lobe narrow to moderately wide, width 25–35% lobe length; moderate length, length approximately 30% glabella length; anterior margin located adjacent to 20–30% glabella length from anterior margin of frontal lobe; furrow shallow to moderate depth. Ocular ridge moderately weak to weak, directed moderately posterolaterally from glabella at 70–75° to axial trend. Posterior area of fixigena exsagittal width 30–40% glabella length; length 40–55% glabella length; bluntly terminated. Posterior border strongly convex, wider slightly distally; border furrow narrow to moderately wide, deep, wider laterally, straight.

Librigena, hypostoma, thorax, and pygidium unknown.

Exoskeleton thin; finely granulated on external surface and internal mold.

REMARKS. *Spencella? utahensa* is most similar to *S.? convexa* Rasetti, 1963, in the moderately to strongly dorsally convex anterior border, but differs in having a more swollen anterior border and less rounded frontal lobe. *Spencella? utahensa* differs from all other species of *Spencella* in having a moderately to strongly dorsally convex anterior border and granular ornamentation.

ETYMOLOGY. Latinized, named after the State of Utah.

HOLOTYPE. Cranidium (LACMIP 11975) from the Trailer Limestone, Dugway Range, Utah (LACMIP locality 15536).

PARATYPES. LACMIP 11974 from LACMIP locality 15495; LACMIP 11976 from LACMIP locality 15538; LACMIP 11977 from LACMIP locality 15541; LACMIP 11978 from LACMIP locality 15580.

OTHER MATERIAL. LACMIP locality 15495, 6 cranidia; LACMIP locality 15496, 5 cranidia; LACMIP locality 15499, 1 cranidium; LACMIP locality 15515, 1 cranidium; LACMIP locality 15516, 1 cranidium; LACMIP locality 15517, 2 cranidia; LACMIP locality 15526, 3 cranidia; LACMIP locality 15528, 1 cranidium; LACMIP locality 15534, 1 cranidium; LACMIP locality 15536, 6 cranidia; LACMIP locality 15538, 2 cranidia; LACMIP locality 15540, 2 cranidia; LACMIP locality 15541, 15



Figure 73. *Trymataspis* cf. *T. depressa* Robison. Small cranidium (LACMIP hypotype 11979), LACMIP locality 15543, partially exfoliated, $\times 10.6$.

cranidia; LACMIP locality 15543, 2 cranidia; LACMIP locality 15547, 1 cranidium; LACMIP locality 15548, 1 cranidium; LACMIP locality 15580, 3 cranidia.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains and House Range, Utah. Trailer Limestone, Dugway Range, Utah. Pole Canyon Limestone, Member E, Patterson Pass.

Genus *Trymataspis* Robison, 1964a

Trymataspis cf. *T. depressa*
Robison, 1964a

Figure 73

REMARKS. A small cranidium that resembles *Trymataspis depressa* Robison, 1964a, was found in the upper portion of the lower member of the Trailer Limestone, Dugway Range. This specimen differs from *T. depressa* in having a shorter glabella and less prominent occipital spine.

HYPOTYPE. LACMIP 11979 from LACMIP locality 15543.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Trailer Limestone, Dugway Range, Utah.

Genus *Yuknessaspis* Rasetti, 1951

TYPE SPECIES. *Yuknessaspis paradoxa* Rasetti, 1951.

EMENDED DIAGNOSIS. Multisegmented, micropygous Ptychopariida with cranidium with moderate length glabella, lateral glabellar furrows shallow to absent, frontal glabellar lobe truncated to slightly rounded, deep preglabellar furrow, anterior portion of axial furrows very deep, straight to concave axial furrows, ocular ridges typically strong, palpebral lobe moderate length, posterior area of fixigenae wider than occipital ring, posterior border furrow distally curved anteriorly, fixigenae moderately wide, convex preglabellar field and anterior area of fixigena, anterior border slightly to strongly convex.

REMARKS. Rasetti (1951) based this genus on three specimens. The diagnosis is modified to reflect the new species *Y. benningtonis*. *Yuknessaspis benningtonis* is a variable species with three subspecies. The subspecies vary considerably in the shape of the frontal area, glabella shape, axial furrows, and posterior area of fixigenae.

Yuknessaspis benningtonis,
new species

Figures 74–76

Yuknessaspis, n. sp. Sundberg, 1991:388, fig. 2.10.

DIAGNOSIS. *Yuknessaspis* with cranidium with medial swelling, downsloping preglabellar field and anterior area of fixigena.

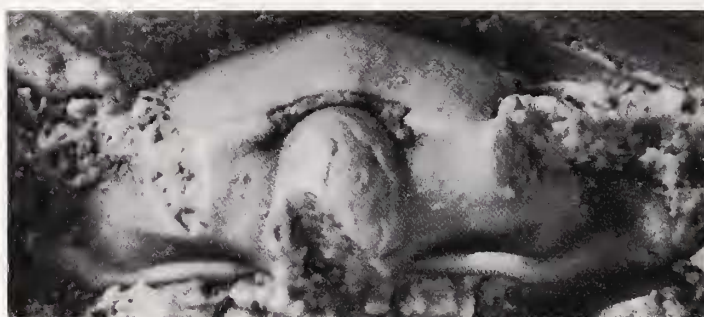


Figure 74. *Yuknessaspis benningtonis benningtonis*, new species and subspecies. 1, Stereo pair of paratype cranidium (LACMIP 11980), LACMIP locality 15495, partially exfoliated, $\times 8.7$. 2, 3, Dorsal and anterior view of holotype cranidium (LACMIP 11983), LACMIP locality 15543, partially exfoliated, $\times 5.0$.

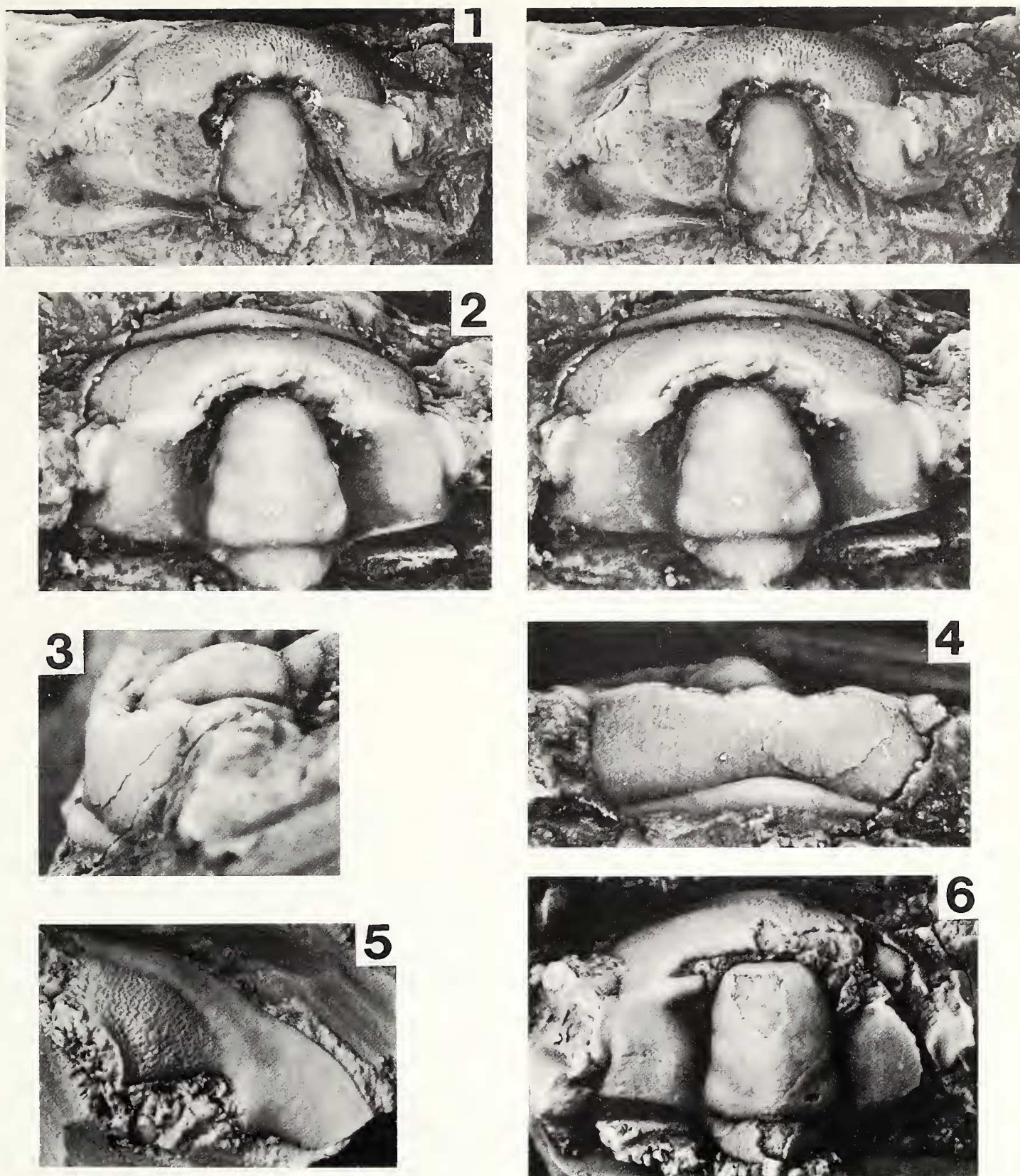


Figure 75. *Yuknessaspis benningtonis convexus*, new species and subspecies. 1, Stereo pair of partial paratype cranidium (LACMIP 11985) with posterior area of fixigena preserved, LACMIP locality 15497, mostly exfoliated, $\times 5.0$. 2–4, Stereo pair, lateral, and anterior view of holotype cranidium (LACMIP 11984), LACMIP locality 15497, partially exfoliated, $\times 10.3$. 5, Paratype free cheek (LACMIP 11987), LACMIP locality 15538, exfoliated, $\times 5.1$. 6, Stereo pair of partial paratype cranidium (LACMIP 11988), LACMIP locality 15538, partially exfoliated, $\times 6.9$.

DESCRIPTION. Cranidium small to moderate size, length 2.2–6.2 mm; subtrapezoidal, length 35–60% width; strong sagittal and moderate transverse convexity, height 20–45% width; anterior margin slightly to moderately curved, anterior margin width 40–70% cranial width; posterior margin, excluding occipital ring, very slightly backswept to lateral margins curved anteriorly. Facial sutures parallel to moderately divergent from ends of palpebral lobes to halfway to anterior border; moderately convergent from halfway to anterior border to across an-

terior border; very strongly divergent posterior of palpebral lobes. Glabella moderate length, length 65–70% and width 40–55% cranial plan view length; glabella width 20–30% cranial width; moderately to very strongly tapered, width at anterior end 55–80% glabellar width; moderate convexity (sag. and trans.); frontal lobe bluntly rounded to truncated, 3 lateral glabellar lobes. Axial furrows very deep to moderately deep anterior of ocular ridge, shallower posteriorly, straight to slightly convex; preglabellar furrow moderate depth to deep,

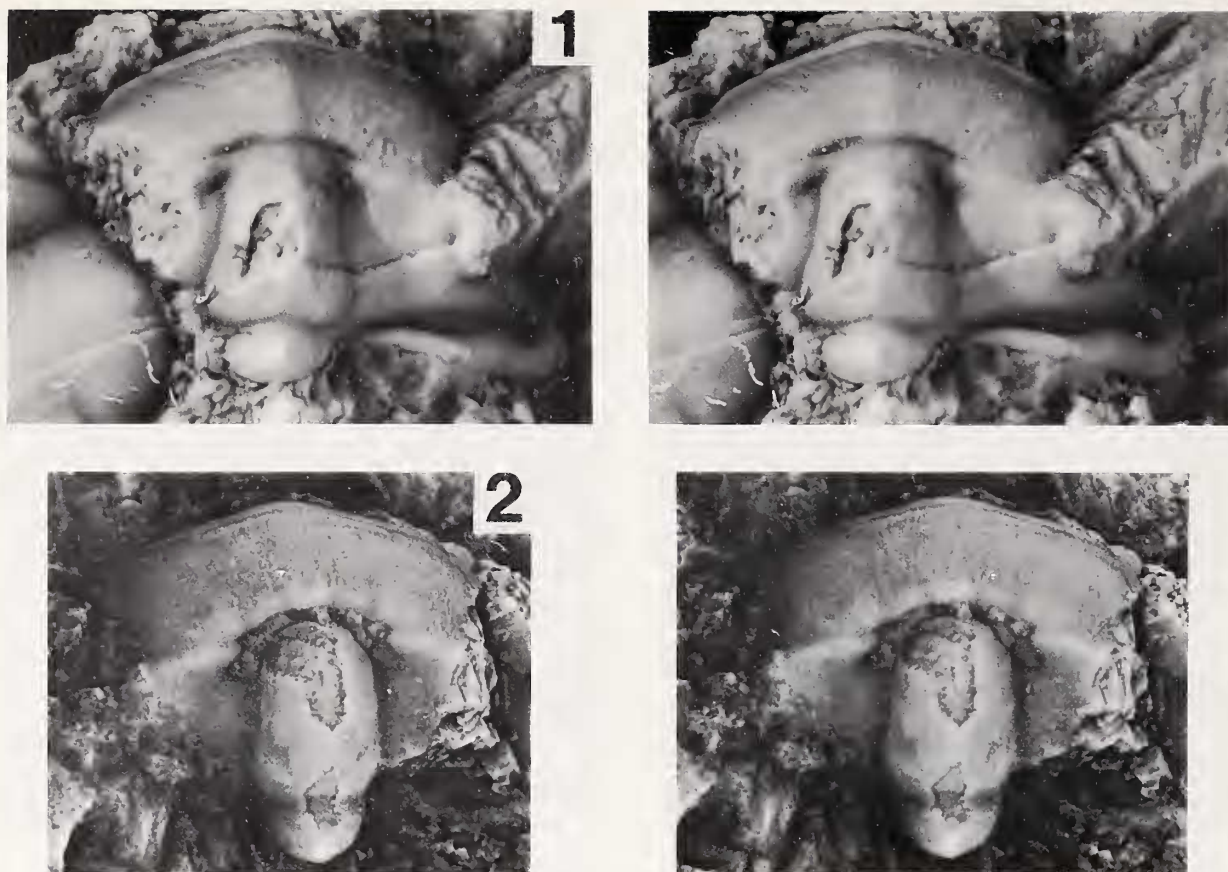


Figure 76. *Yuknessaspis benningtonis planus*, new species and subspecies. 1, Stereo pair of holotype cranidium (LACMIP 11990), LACMIP locality 15548, exfoliated, $\times 7.5$. 2, Stereo pair of small paratype cranidium (LACMIP 11989), LACMIP locality 15495, slightly exfoliated, $\times 10.8$.

slightly curved; lateral glabellar furrows very shallow, F1 furrow bifurcated, directed posteriorly, F2 furrow directed slightly posteriorly, F3 furrow directed laterally. Occipital ring sagittal length 20–35% glabellar length, not elevated above glabella, moderately convex; small occipital node; furrow curved anteriorly, moderate depth, deeper laterally; posterior margin moderately curved. Frontal area plan view length 25–30% cranidial plan view length, unequally divided. Preglabellar field slightly to moderately convex, moderately to very strongly downsloping, plan view length 80–100% frontal area plan view length; medial swelling, low sagittally elongate to high to low round. Anterior border slightly to strongly convex, level, slightly to moderately tapering laterally, evenly to unevenly curved, sagittal plan view length 0–20% frontal area plan view length. Anterior border furrow evenly to unevenly curved, very shallow to moderate depth, slightly to greatly shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 65–80% glabellar width, very low convexity, upsloping. Palpebral lobe narrow to moderate width, width 25–35% lobe length; moderate length, length 35–40% glabellar length; anterior margin located adjacent to 5–25% glabellar length from anterior margin of frontal lobe; furrow very shallow to shallow. Ocular ridge strong adjacent to glabella, moderately strong laterally, directed slightly posterolaterally from glabella at 75–85° to axial trend. Posterior area of fixigena exsagittal width 35–50% glabellar length; length 90–155% glabella length; projecting slightly posteriorly to bending strongly anteriorly;

roundly terminated. Posterior border high, strongly convex, wider laterally, curving partially or completely around border furrow; border furrow narrow, deep, straight to curving posteriorly, distally curved anteriorly, wider laterally.

Librigena moderate size, length 7.1 mm; moderately wide, width approximately 55% length without spine; lateral margin slightly, unevenly curved. Genal field moderately convex, width approximately 60% librigenal width. Border width approximately 20% librigenal width; gently convex; lateral border furrow shallow, shallowing anteriorly; posterior border furrow absent. Genal spine broad based, wide, length unknown.

Hypostoma, thorax, and pygidium unknown.

Exoskeleton thin; coarse to fine genal caeca on preglabellar field, anterior area of fixigena, and genal field of librigena, smooth to scattered moderately coarse granules on cranidia, fine pitting on lateral border and genal spine of librigena on external surface and internal mold.

REMARKS. *Yuknessaspis benningtonis* contains three new subspecies, *Y. benningtonis benningtonis*, *Y. benningtonis convexus*, and *Y. benningtonis planus*. The subspecies occur either together or within short stratigraphic intervals (less than 1 m), suggesting they are different morphologies of the same species. In the Dugway Range, the three subspecies occur within a 0.6-m-thick sequence of bioclastic limestones at the top of the lower unit of the Trailer Limestone. *Yuknessaspis benningtonis convexus* occurs in the lower 30 cm of section; *Y. benningtonis benningtonis* occurs in

the next 10 cm of strata; and *Y. benningtonis planus* occurs in the upper 15 cm of the section. In the Drum Mountains, *Y. benningtonis benningtonis* and *Y. benningtonis planus* occur together in the same bed with some specimens with intermediate morphologies, which suggests a close relationship of at least these two, very different looking subspecies.

Yuknessaspis benningtonis differs from *Y. paradoxa* Rasetti in having a downsloping preglabellar field and anterior area of fixigena and a medial swelling.

ETYMOLOGY. Latinized, named for the collector of the holotype, J Bret Bennington.

HOLOTYPE. Cranidium (LACMIP 11983) from the Trailer Limestone, Dugway Range, Utah (LACMIP locality 15543).

PARATYPES. See subspecies.

OTHER MATERIAL. See subspecies.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. See subspecies.

Yuknessaspis benningtonis benningtonis, new subspecies

Figure 74

Yuknessaspis, n. sp. Sundberg, 1991:388, fig. 2.10.

DIAGNOSIS. *Yuknessaspis benningtonis* with cranidium with sagittally elongate, low, medial swelling; very strong to moderately strong downsloping preglabellar field and anterior area of fixigena; slightly tapered glabella; posterior portion of axial furrows shallow; slightly convex anterior border; transversely long (115–155% glabellar length), anteriorly bent posterior area of fixigenae.

REMARKS. *Yuknessaspis benningtonis benningtonis* differs from *Y. benningtonis convexus* in having a more tapered glabella, longer posterior area of fixigenae that are backswept, shallower axial furrows, slightly convex anterior border, less steeply downsloping preglabellar field, elongate and low medial swelling, and no genal caeca on the preglabellar field and anterior area of fixigena. *Yuknessaspis benningtonis benningtonis* differs from *Y. benningtonis planus* in having a stronger downsloping preglabellar field and anterior area of fixigena, converging facial sutures anterior of palpebral lobes, longer posterior area of fixigenae that are anteriorly bent, and slightly convex anterior border. Specimens found in the Drum Mountains show variation in the degree of downsloping of the frontal region indicating that the variation of the subspecies ranges into the morphological realm of *Y. benningtonis planus*.

ETYMOLOGY. Latinized, named for my field partner, J Bret Bennington.

HOLOTYPE. Cranidium (LACMIP 11983) from the Trailer Limestone, Dugway Range, Utah (LACMIP locality 15543).

PARATYPES. LACMIP 11980–11982 from LACMIP locality 15495.

OTHER MATERIAL. LACMIP locality 15495, 1 cranidium; LACMIP locality 15580, 1 cranidium.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains, Utah. Trailer Limestone, Dugway Range, Utah. Pole Canyon Limestone, Member E, Patterson Pass, Nevada.

Yuknessaspis benningtonis convexus, new subspecies

Figure 75

DIAGNOSIS. *Yuknessaspis benningtonis* with cranidium with rounded very weak to moderately strong medial swelling; very strong downsloping preglabellar field and anterior area of fixigena forming sharp flexure in front of glabella; slightly tapered glabella; posterior portion of axial furrows deep; moderately to strongly convex anterior border; transversely shorter (100–110% glabellar length) slightly backswept posterior area of fixigenae.

REMARKS. *Yuknessaspis benningtonis convexus* differs from *Y. benningtonis benningtonis* as discussed above. *Yuknessaspis benningtonis convexus* differs from *Y. benningtonis planus* in having a strongly downsloping preglabellar field and anterior area of fixigena, round medial swelling, convergent facial sutures anterior of palpebral lobes, moderately coarse genal caeca on frontal region, and deeper posterior portion of the axial furrows.

The librigena described above belongs to this subspecies.

ETYMOLOGY. Latin, named for the convex frontal region.

HOLOTYPE. Cranidium (LACMIP 11984) from the Swasey Limestone, Drum Mountains, Utah (LACMIP locality 15497).

PARATYPES. LACMIP 11985 from LACMIP locality 15497; LACMIP 11986–11988 from LACMIP locality 15538.

OTHER MATERIAL. LACMIP locality 15498, 1 cranidium; LACMIP locality 15536, 1 cranidium; LACMIP locality 15538, 4 cranidia; LACMIP locality 15540, 2 cranidia; LACMIP locality 15541, 2 cranidia; LACMIP locality 15568, 1 cranidium.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains, Utah. Trailer Limestone, Dugway Range, Utah. Pole Canyon Limestone, Member E, Snake Range, Nevada.

Yuknessaspis benningtonis planus, new subspecies

Figure 76

DIAGNOSIS. *Yuknessaspis benningtonis* with cranidium with sagittally elongate medial swelling; moderately downsloping preglabellar field and anterior area of fixigena, tapered glabella, posterior portion of axial furrows shallow; moderately convex anterior border; transversely shorter (approx-

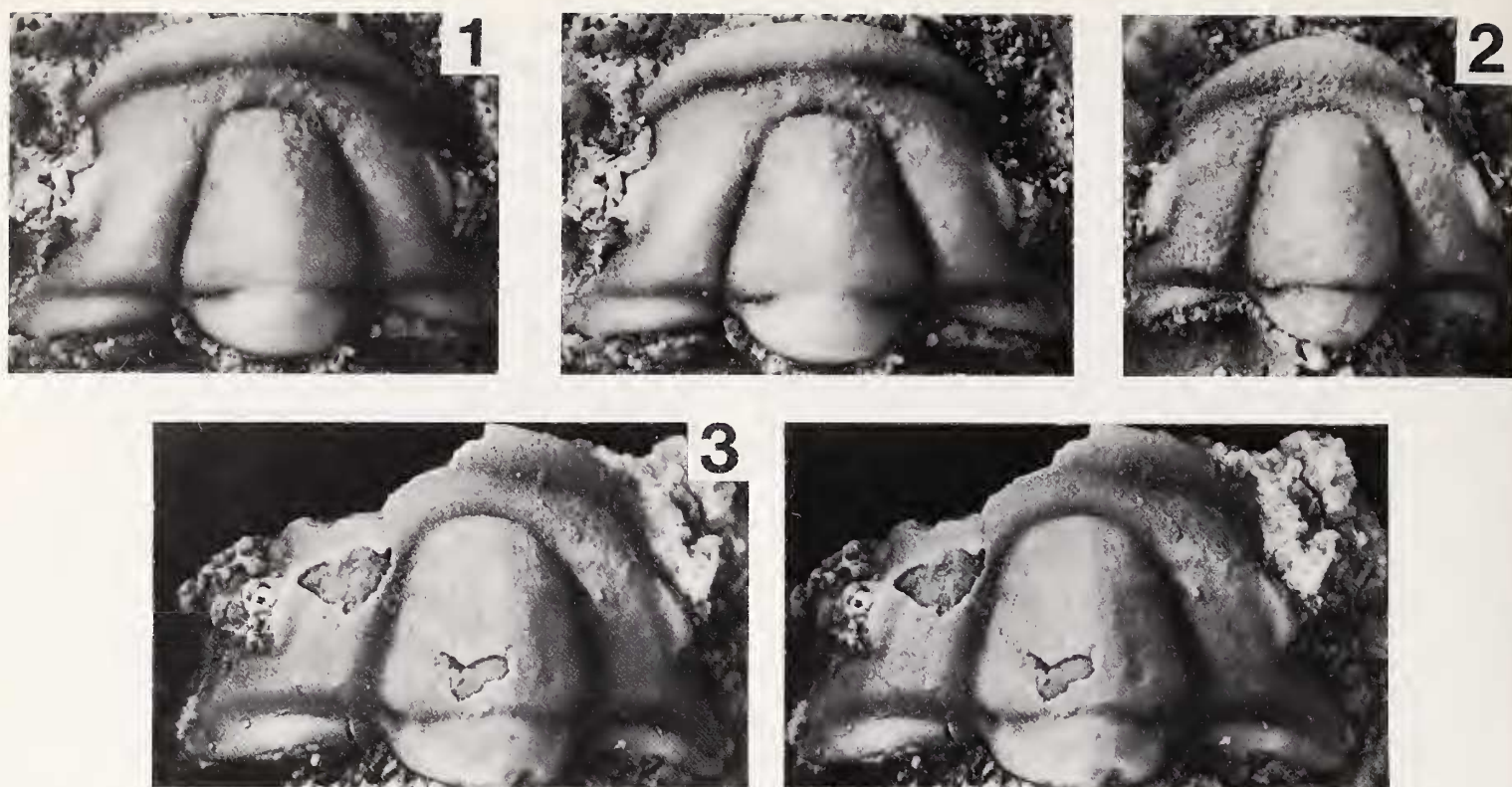


Figure 77. Ptychopariida sp. unidet. 1, Stereo pair of cranidium (LACMIP hypotype 12009), LACMIP locality 15492, not exfoliated, $\times 9.8$. 2, Cranidium (LACMIP hypotype 11961), LACMIP locality 15489, not exfoliated, $\times 11.4$. 3, Stereo pair of cranidium (LACMIP hypotype 350), LACMIP locality 15492, partially exfoliated, $\times 8.4$.

mately 90% glabellar length), slightly backswept posterior area of fixigenae.

REMARKS. *Yuknessaspis benningtonis planus* differs from *Y. benningtonis benningtonis* and *Y. benningtonis concava* as discussed above. *Yuknessaspis benningtonis planus* is similar to the *Y. paradoxa* but differs in having a rounded frontal lobe, shallower axial furrows, moderately convex anterior border, and weaker genal caeca in the frontal region.

ETYMOLOGY. Latin, *planus* = level, for the relatively level preglabellar field.

HOLOTYPE. Cranidium (LACMIP 11990) from the Trailer Limestone, Dugway Range, Utah (LACMIP locality 15548).

PARATYPE. LACMIP 11989 from LACMIP locality 15495.

OTHER MATERIAL. LACMIP locality 15545, 2 cranidia; LACMIP locality 15547, 1 cranidium.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains, Utah. Trailer Limestone, Dugway Range, Utah.

Genus Uncertain

Ptychopariida sp. A

Figure 77

DESCRIPTION. Cranidium small, length 2.4–3.9 mm; subtrapezoid, length 70–80% width; moderately low convexity (sag. and trans.), height 25–35% width; anterior margin slightly to moderately curved, anterior margin width 65–80% cranidial width; posterior margin, excluding occipital ring, slightly backswept. Facial sutures parallel to slightly

divergent from ends of palpebral lobes to half the distance of the anterior border; moderately to strongly convergent across anterior portion of anterior border; strongly divergent posterior of palpebral lobes. Glabella elongate, length 75–80% and width 50–60% cranidial length; glabella width 40–45% cranidial width; very strongly to slightly tapered, width at anterior end 55–90% glabellar width; moderate convexity (sag. and trans.); frontal lobe moderately to bluntly rounded, 3(?) lateral glabellar lobes. Axial furrows moderate depth, deeper posteriorly, slightly concave to straight; preglabellar furrow shallow to moderate depth, moderately to slightly curved; lateral glabellar furrows very shallow or absent. Occipital ring sagittal length 25–30% glabellar length, elevated above glabella, moderately convex; very weak occipital node; anteriorly curved furrow, deeper laterally, shallowing medially, moderately deep; posterior margin moderately curved, flattened medially. Frontal area length approximately 25% cranidial length, subequally divided. Preglabellar field slightly concave, downsloping, length 40–45% frontal area length. Anterior border strongly convex to flat, level, slightly to strongly tapering laterally, evenly curved, sagittal length 55–60% frontal area length. Anterior border furrow evenly curved, narrow, moderately shallow to moderate depth, shallower medially, shallower than axial furrows. Fixigena width, exclusive of palpebral lobe, 40–50% glabellar width, low convexity, level to slightly downsloping; anterior area of fixigena moderately downsloping. Palpebral lobe narrow to wide, width 20–35% lobe length; moderate length, length 30–35% glabellar length; anterior margin located adjacent to 15–20% glabellar

length from anterior margin of frontal lobe; furrow shallow depth. Ocular ridge weak, directed moderately posterolaterally from glabella at 65–75° to axial trend. Posterior area of fixigena exsagittal width 35–40% glabellar length; length 50–60% glabella length; bluntly terminated. Posterior border strongly convex, wider slightly distally; border furrow narrow, deep, wider laterally, curved slightly posteriorly.

Librigena, hypostoma, thorax, and pygidium unknown.

Exoskeleton thin; smooth on external and internal surfaces.

REMARKS. The nomenclature of Ptychopariida sp. A is left open even though several specimens are known. Although the species is of the general ptychopariid morphology, it cannot be placed in any established genus. Specimens are variable in glabellar shape and anterior border convexity and tapering. These features are typically used to differentiate genera and species, but the mixing of characters so that no clear separation can be made suggests that these specimens belong to only one species. More specimens are needed from individual localities to establish intrapopulation variation. Ptychopariida sp. A can be separated from *Deltina* in having a smaller glabella, shallower lateral glabellar furrows, and concave axial furrows. Ptychopariida sp. A can also be separated from *Spencella* in having longer posterior area of fixigenae and more tapering, less elevated, conical glabella.

HYPOTYPES. LACMIP 11961 from LACMIP locality 15489; LACMIP 12009, 12010 from LACMIP locality 15492.

OTHER MATERIAL. LACMIP locality 15489, 2 cranidia; LACMIP locality 15491, 1 cranidium; LACMIP locality 15493, 2 cranidia; LACMIP locality 15527, 1 cranidium; LACMIP locality 15532, 4 cranidia; LACMIP locality 15533, 3 cranidia; LACMIP locality 15534, 3 cranidia.

OCCURRENCE. *Altiocculus* Subzone, *Ehmaniella* Biozone. Swasey Limestone, Drum Mountains, Utah. Trailer Limestone, Dugway Range, Utah.

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APPENDIX: LOCALITY REGISTER

DRUM MOUNTAINS

SECTIONS. Ch1, Do1, Do2, W1, Sw1, Sw2, and B1.

LOCATION. Section 17, T. 15 S., R. 11 W., USGS topographic map Drum Mts. Well 7.5' Quadrangle, Utah (1971); Drum Mountains, Millard County, Utah (Fig. 78).

DESCRIPTION. The measured sections in the Drum Mountains cover an incomplete interval of the Chisholm Formation (54.5 m, sections Ch1 and Do1) and complete intervals of the Dome Limestone (54.7 m, section Do2), Whirlwind Formation (42.5 m, section W1), and Swasey Limestone (60.5 m, sections Sw1 and Sw2) (Figs. 79–81). A short interval from the uppermost Swasey and lowermost Wheeler Shale (1.55 m, section B1) was also measured and collected. The sections were measured in northward-trending canyons approximately 1.1 km (0.7 mi) north-northwest of the proposed stratotype for agnostid biozones in the Wheeler Shale (Rowell et al., 1982).

FOSSIL LOCALITIES.

LACMIP 15454. Chisholm Formation, section Do1, 47 m above base of section, float.

LACMIP 15455. Chisholm Formation, section Do2, 2.0 m above base of section, collected adjacent to section from float.

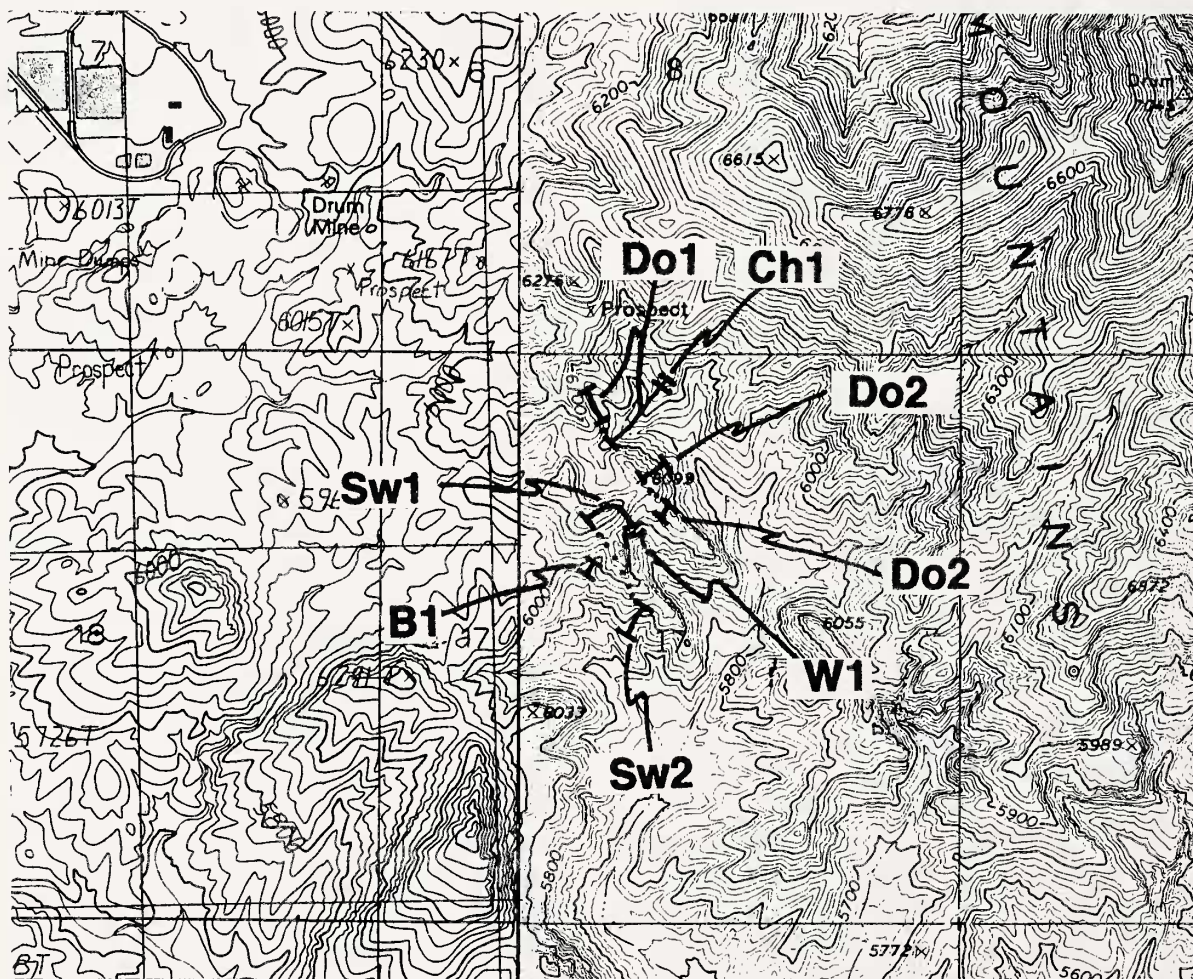


Figure 78. Location of stratigraphic sections in the Drum Mountains, Utah. From Drum Mts. Well (1971) and Lady Laird Peak (1988) 7.5' quadrangles. Contour intervals 20 and 40 ft.

LACMIP 15456. Chisholm Formation, section Do2, 2.35 m above base of section.

LACMIP 15457. Chisholm Formation, section Do2, 2.37 m above base of section.

LACMIP 15458. Chisholm Formation, section Do2, 2.39 m above base of section.

LACMIP 15459. Chisholm Formation, section Do2, 4.0-4.5 m above base of section, float.

LACMIP 15460. Chisholm Formation, section Do2, 5.0 m above base of section, float.

LACMIP 15461. Chisholm Formation, section Do2, 6.0 m above base of section.

LACMIP 15462. Dome Limestone, section Do2, 39.5 m above base of section.

LACMIP 15463. Dome Limestone, section W1, 2.0 m above base of section.

LACMIP 15464. Dome Limestone, section W1, 3.2 m above base of section.

LACMIP 15465. Whirlwind Formation, section W1, 20.6 m above base of section.

LACMIP 15466. Whirlwind Formation, section W1, 21.2 m above base of section.

LACMIP 15467. Whirlwind Formation, section W1, 28.9 m above base of section.

LACMIP 15468. Whirlwind Formation, section W1, 29.4 m above base of section.

LACMIP 15469. Whirlwind Formation, section W1, 29.9 m above base of section.

LACMIP 15470. Whirlwind Formation, section W1, 30.9 m above base of section.

LACMIP 15471. Whirlwind Formation, section W1, 31.5 m above base of section.

LACMIP 15472. Whirlwind Formation, section W1, 34.9 m above base of section.

LACMIP 15473. Whirlwind Formation, section W1, 35.8 m above base of section.

LACMIP 15474. Whirlwind Formation, section W1, 37.6 m above base of section.

LACMIP 15475. Whirlwind Formation, section W1, 42.0 m above base of section, float.

LACMIP 15476. Swasey Limestone, section Sw1, 0.4 m above base of section.

LACMIP 15477. Swasey Limestone, section Sw1, 0.7 m above base of section.

LACMIP 15478. Swasey Limestone, section Sw1, 1.2 m above base of section.

LACMIP 15479. Swasey Limestone, section Sw1, 1.6 m above base of section.

LACMIP 15480. Swasey Limestone, section Sw1, 4.5 m above base of section.

LACMIP 15481. Swasey Limestone, section Sw1, 5.0 m above base of section.

LACMIP 15482. Swasey Limestone, section Sw1, 6.3 m above base of section.

LACMIP 15483. Swasey Limestone, section Sw1, 9.1 m above base of section.

LACMIP 15484. Swasey Limestone, section Sw1, 16.8 m above base of section.

LACMIP 15485. Swasey Limestone, section Sw1, 18.2 m above base of section.

LACMIP 15486. Swasey Limestone, section Sw1, 19.7 m above base of section.

LACMIP 15489. Swasey Limestone, section Sw2, 19.7 m above base of section.

LACMIP 15490. Swasey Limestone, section Sw2, 20.5 m above base of section.

LACMIP 15491. Swasey Limestone, section Sw2, 21.5 m above base of section.

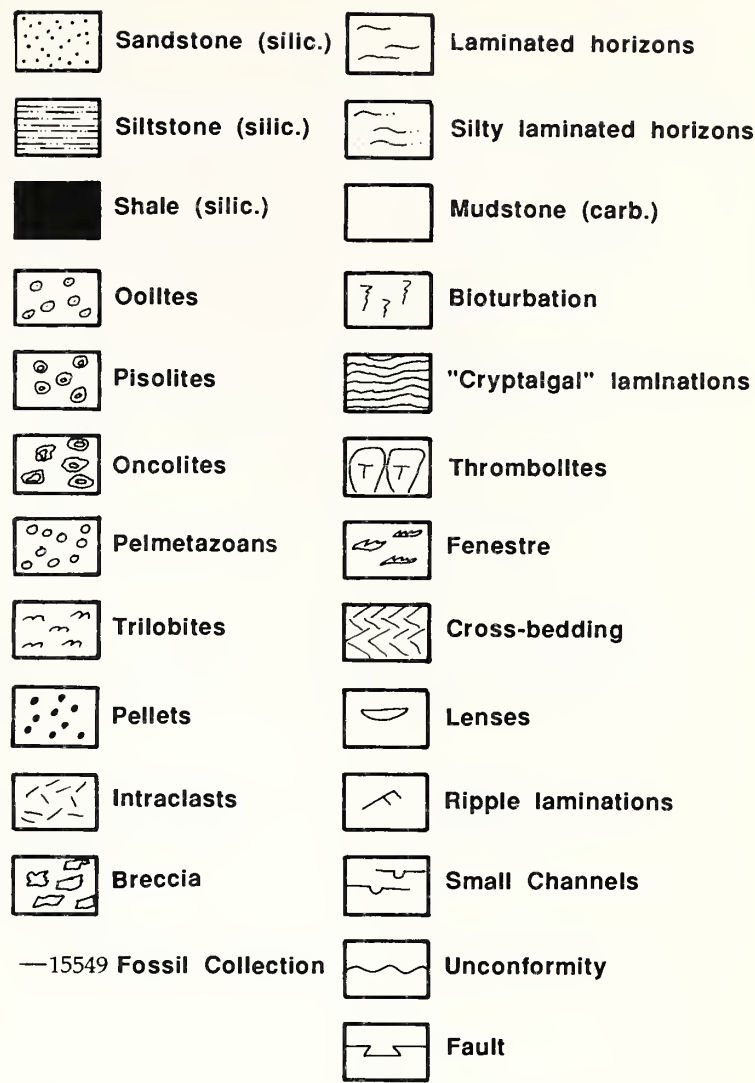


Figure 79. Lithologic symbols used for the following stratigraphic sections.

LACMIP 15492. Swasey Limestone, section Sw2, 22.8 m above base of section.

LACMIP 15493. Swasey Limestone, section Sw2, 23.5 m above base of section.

LACMIP 15494. Swasey Limestone, section Sw2, 24.0 m above base of section.

LACMIP 15495. Swasey Limestone, section Sw2, 37.7 m above base of section.

LACMIP 15496. Swasey Limestone, section Sw2, 37.6 m above base of section.

LACMIP 15497. Uppermost Swasey Limestone, section B1, -1.27 m below top of section.

LACMIP 15498. Uppermost Swasey Limestone, section B1, -1.05 m below top of section.

LACMIP 15499. Uppermost Swasey Limestone, section B1, -0.60 m below top of section.

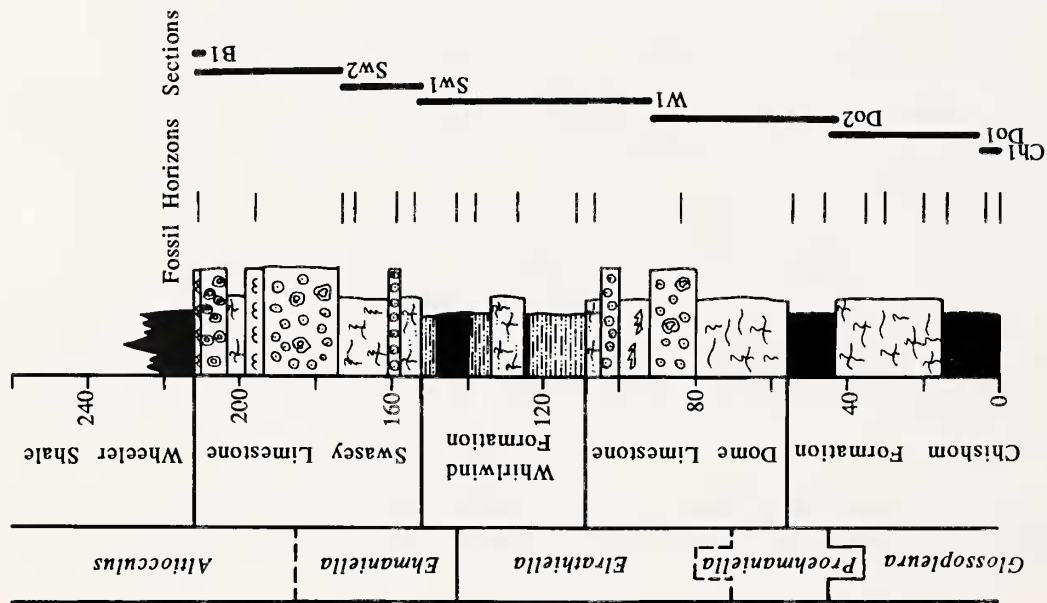
LACMIP 15500. Uppermost Swasey Limestone, section B1, -0.25 to -0.40 m below top of section.

HOUSE RANGE

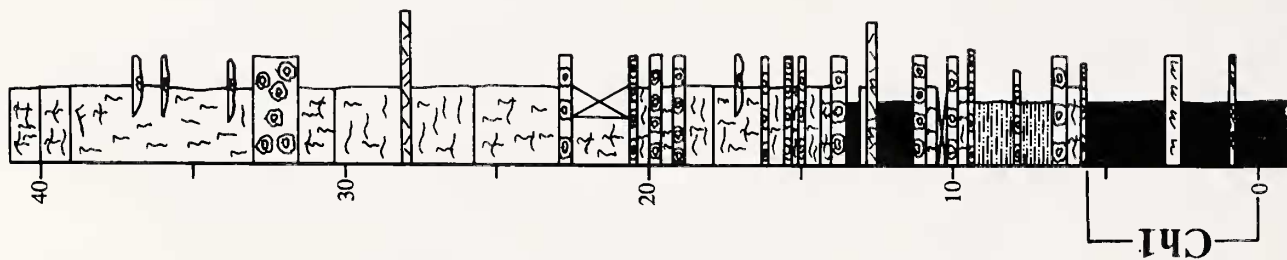
SECTIONS. Ch2, Do3, W2, Sw3, and B3.

LOCATIONS. Ch2—section 21 (projected), T. 18 S., R. 14 W., USGS topographic map Notch Peak 15' Quadrangle, Utah (1960); House Range, Millard County, Utah (Fig. 82A). Do3, W2, and Sw3—section 14 (projected), T. 18 S., R. 14 W., USGS topographic map Notch Peak 15' Quadrangle, Utah (1960); House Range, Millard County, Utah (Fig. 82A). B3—section 34 (projected), T. 17 S., R. 13 W., USGS topographic map Marjum Pass 7.5' Quad-

Drum Mountains



Do1



Do2

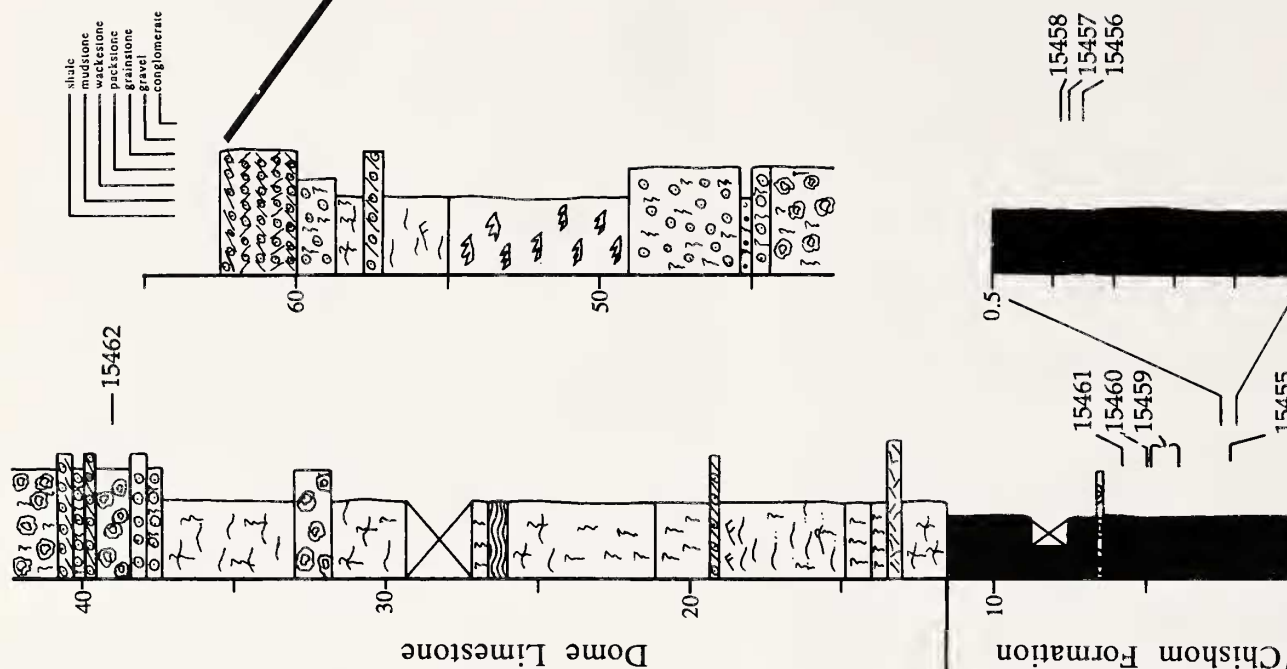


Figure 80. Generalized stratigraphic section of the *Ehmaniella* Biozone in the Drum Mountains, Utah, and detailed sections Do1 and Do2 showing LACMIP localities. (See Fig. 79 for lithologic symbols.)

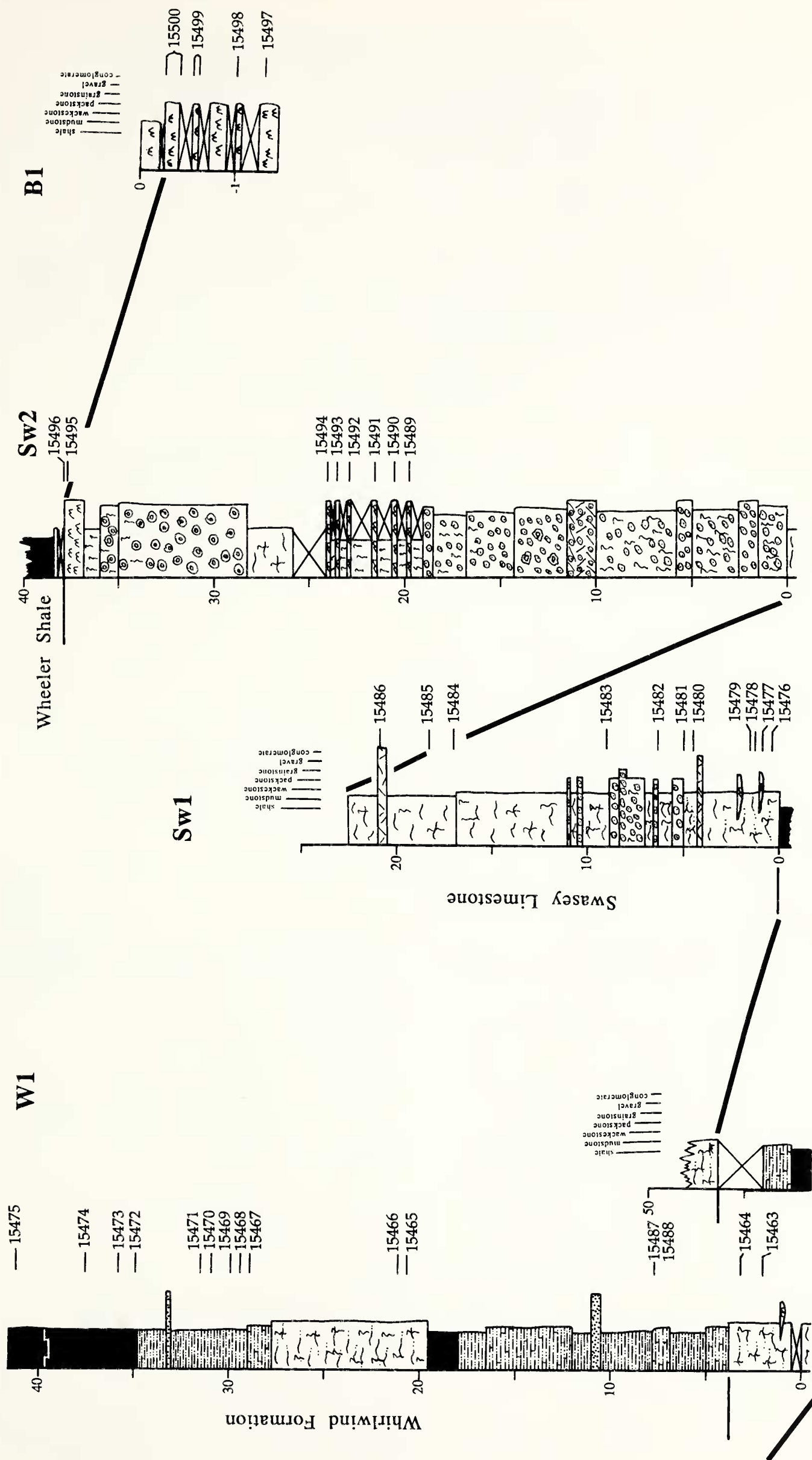


Figure 81. Detailed sections W1, Sw1, Sw2, and B1 from the Drum Mountains showing LACMIP localities. (See Fig. 79 for lithologic symbols.)

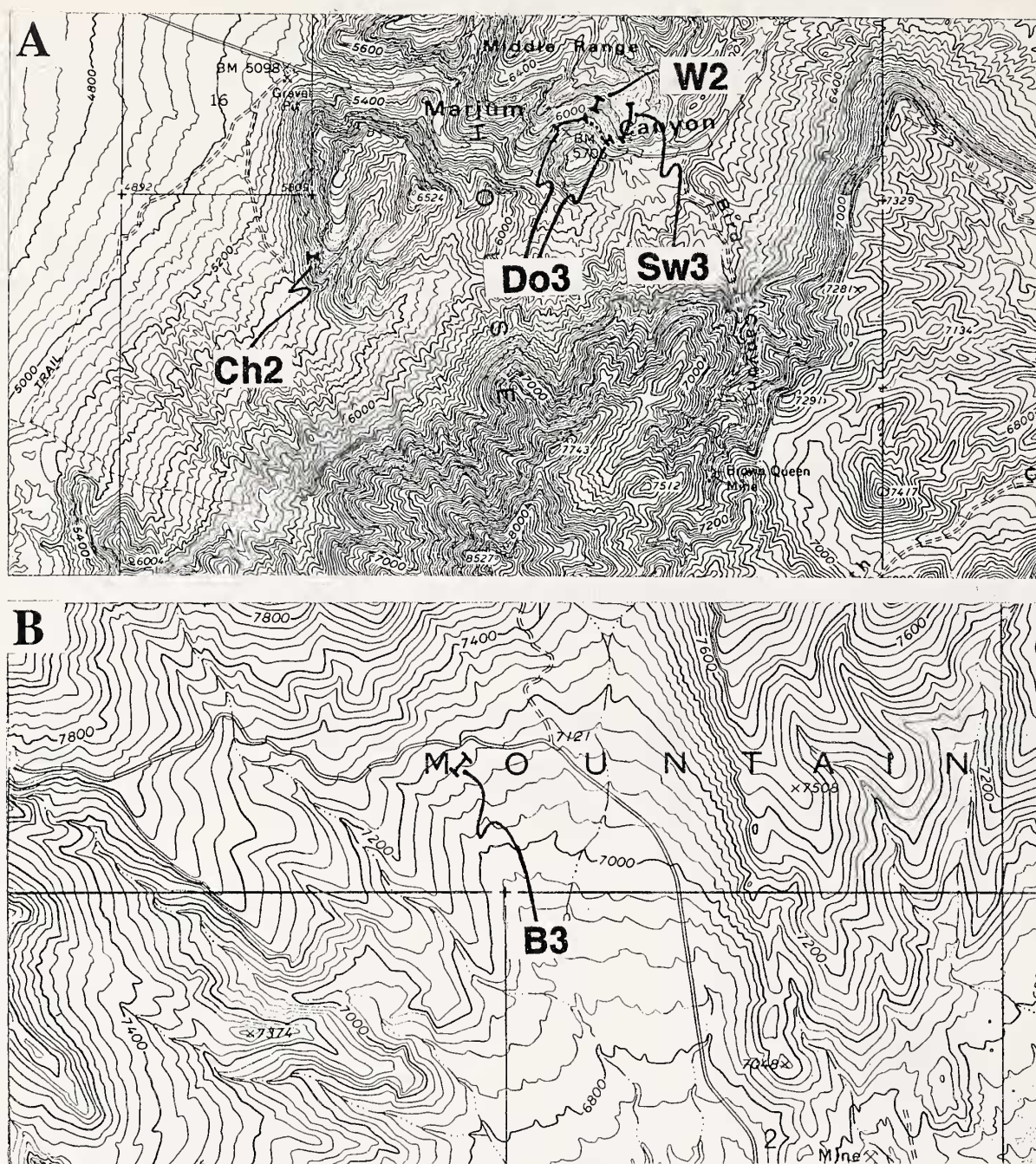


Figure 82. Location of stratigraphic sections in the House Range, Utah. **A**, From Marjum Pass 7.5' Quadrangle (1972); **B**, from Notch Peak 15' Quadrangle (1960). Contour intervals 20 and 40 ft.

range, Utah (1972); House Range, Millard County, Utah (Fig. 82B).

DESCRIPTION. The measured sections in the House Range cover an incomplete interval of the Chisholm Formation (50 m, section Ch2) and complete intervals of the Dome Limestone (90.5 m, sections Ch2 and Do3), Whirlwind Formation (44.5 m, section W2), and Swasey Limestone (60.5 m, sections W2 and Sw3) (Figs. 83 and 84). A short interval from the uppermost Swasey and lowermost Wheeler Shale (5.0 m, section B3) was also measured and collected. The sections for the Dome Limestone (Do3), Whirlwind Formation (W2), and Swasey Limestone (Sw3) were measured on the northern face in eastern Marjum Canyon approximately 2.8 km (1.75 mi) east-northeast from Marjum Pass. The section for the lower Dome and Chisholm Formation (Ch2) was measured on the western front of the House Range approximately 1.6 km (1.0 mi) due south of Marjum Canyon. Section B3 was measured west of the Wheeler Amphitheater approximately 1.8 km (1.15 mi) east of Stove Spring.

FOSSIL LOCALITIES.

LACMIP 15501. Chisholm Formation, section Ch2, 47.0 m above base of section.

LACMIP 15502. Chisholm Formation, section Ch2, 45.0 m above base of section.

LACMIP 15503. Dome Limestone, section Do3, 51.8 m above base of section.

LACMIP 15504. Whirlwind Formation, section W2, 6.0–7.0 m above base of section, float.

LACMIP 15505. Whirlwind Formation, section W2, 6.5 m above base of section.

LACMIP 15506. Whirlwind Formation, section W2, 13.0–13.5 m above base of section, float material.

LACMIP 15507. Whirlwind Formation, section W2, 14.5 m above base of section.

LACMIP 15508. Whirlwind Formation, section W2, 25.0 m above base of section.

LACMIP 15509. Whirlwind Formation, section W2, 36.9 m above base of section.

LACMIP 15510. Whirlwind Formation, section W2, 37.2 m above base of section.

LACMIP 15511. Whirlwind Formation, section W2, 39.3 m above base of section.

LACMIP 15512. Swasey Limestone, section W2, 44.5 m above base of section, collected along strike approximately 10 m southwest of section.

LACMIP 15513. Swasey Limestone, section W2, 45.4 m above base of section.

LACMIP 15514. Swasey Limestone, section Sw3, 62.0 m above base of section.

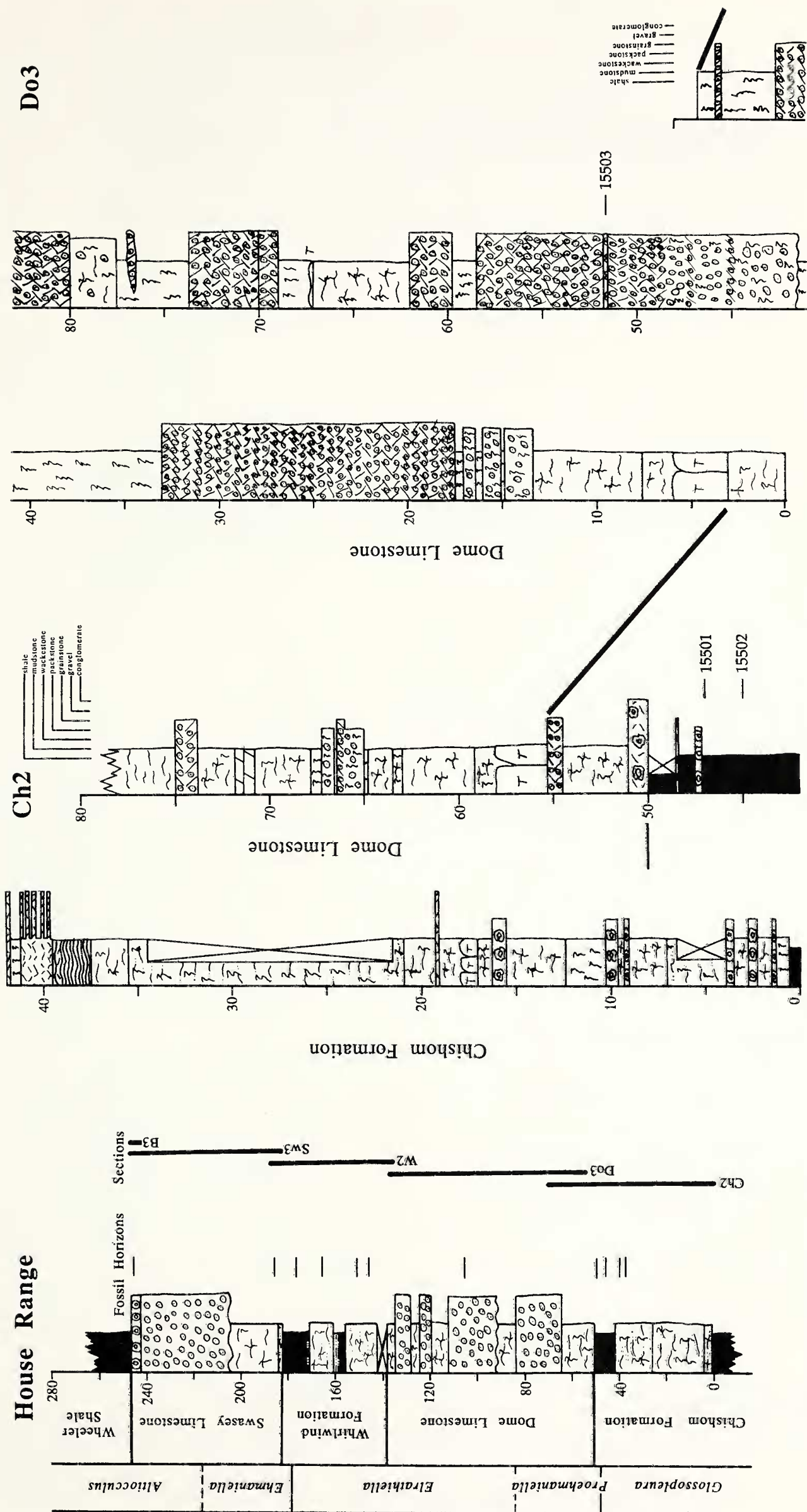


Figure 83. Generalized stratigraphic section of the *Ehmaniella* Biozone in the House Range, Utah, and detailed sections Ch2 and Do3 showing LACMIP localities. (See Fig. 79 for lithologic symbols.)

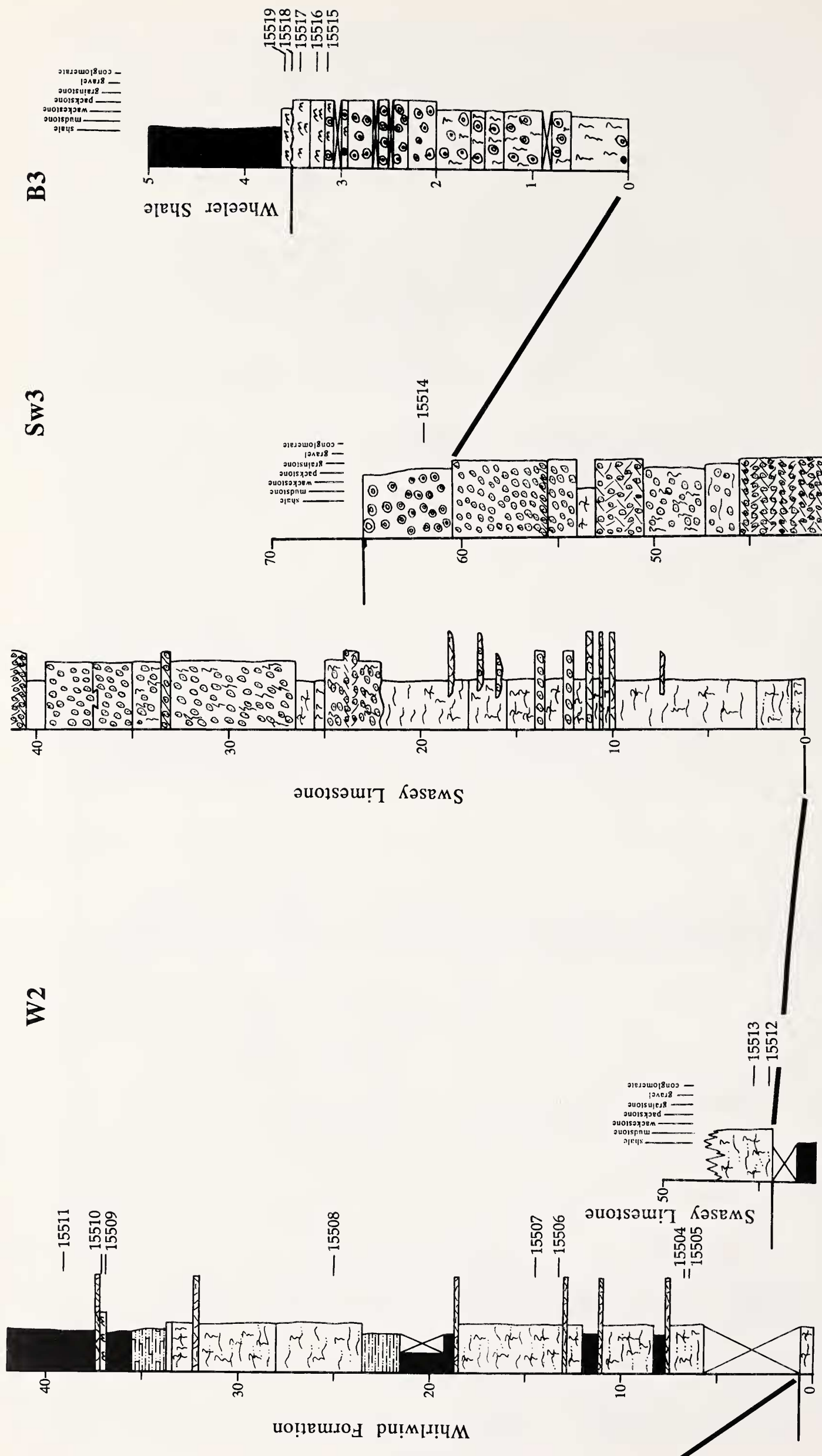


Figure 84. Detailed sections W2, Sw3, and B3 from the House Range showing LACMIP localities. (See Fig. 79 for lithologic symbols.)

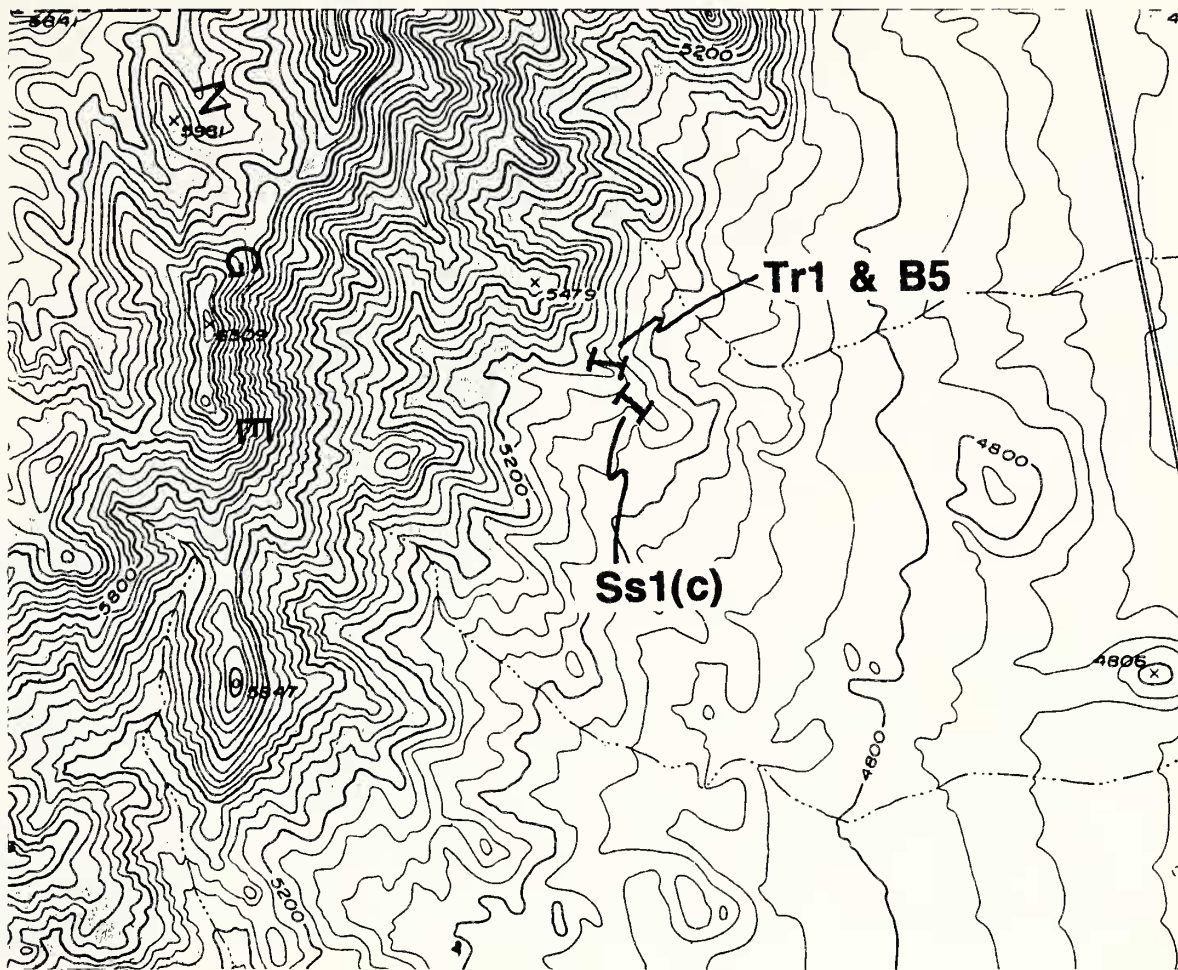


Figure 85. Location of stratigraphic sections in the Dugway Range, Utah. From Dugway Range NE 7.5' Quadrangle (1953). Contour interval 40 ft.

- LACMIP 15515. Uppermost Swasey Limestone, section B3, 3.14 m above base of section.
- LACMIP 15516. Uppermost Swasey Limestone, section B3, 3.27 m above base of section.
- LACMIP 15517. Uppermost Swasey Limestone, section B3, 3.44 m above base of section.
- LACMIP 15518. Uppermost Swasey Limestone, section B3, 3.51 m above base of section.
- LACMIP 15519. Uppermost Wheeler Shale, section B3, 3.60 m above base of section.
- RC 107. Dome Limestone, collected approximately 23 m above the base of the formation. North side of Marjum Canyon, approximately 1.6 km east of canyon mouth, House Range, Millard Co., Utah. Collected by R. Robison, 1967.
- RC 211. Dome Limestone, collected from a large block at the base of the Dome Limestone cliff on a northeast-trending ridge approximately 1.7 km from the east end of Marjum Canyon. The fossils are from approximately 5 m below the top of the block. (Redescribed from Oldroyd [1973] and KUMIP locality cards.) Collected by John D. Oldroyd.
- RC 374. Dome Limestone approximately 23 m above base of formation(?). North side of isolated pinnacle adjacent to massive cliff on north side of Marjum Cyn. NW¼, NE¼, SW¼, section 15, T. 18 S., R. 14 W., Notch Peak (same as 107 and 211). Collectors Robison and Oldroyd, 1975.
- RC 375. Dome Limestone at base of slope southeast of KUMIP locality 374; talus from unknown unit. Collector Oldroyd, 1975.

DUGWAY RANGE

SECTIONS. Ss1(c), Tr1, and B5.
LOCATION. Section 3 (projected), T. 11 S., R. 11 W.,

USGS topographic map Dugway Range 7.5' Quadrangle, Utah (1953); Dugway Range, Juab County, Utah (Fig. 85).
DESCRIPTION. The measured sections in the Dugway Range cover incomplete intervals of the Shadscale Formation (32 m, section Ss1[c]) and Trailer Limestone (37.5 m, sections Tr1 and B5) (Fig. 86). Section B5 consists of the upper 12.5 m of section Tr1. The sections are located on low-lying hills on the southeast side of the Dugway Range approximately 3.7 km (2.3 mi) west-northwest of the Dugway Topaz Well and 1.1 mi north of Shadscale Canyon.
FOSSIL LOCALITIES.

- LACMIP 15520. Shadscale Formation, section Ss1(c), 4.6 m above base of section.
- LACMIP 15521. Shadscale Formation, section Ss1(c), 6.7 m above base of section, float.
- LACMIP 15522. Shadscale Formation, section Ss1(c), 11.3 m above base of section, float.
- LACMIP 15523. Shadscale Formation, section Ss1(c), 13.8 m above base of section, float.
- LACMIP 15525. Shadscale Formation, section Ss1(c), 23.5 m above base of section, float.
- LACMIP 15526. Lower Trailer Limestone, sections B5 and Tr1, 25.80 m above base of sections.
- LACMIP 15527. Lower Trailer Limestone, sections B5 and Tr1, 25.95 m above base of sections.
- LACMIP 15528. Lower Trailer Limestone, sections B5 and Tr1, 26.75 m above base of sections.
- LACMIP 15529. Lower Trailer Limestone, sections B5 and Tr1, 27.05 m above base of sections.
- LACMIP 15530. Lower Trailer Limestone, sections B5 and Tr1, 27.15 m above base of sections.
- LACMIP 15531. Lower Trailer Limestone, sections B5 and Tr1, 27.37 m above base of sections.

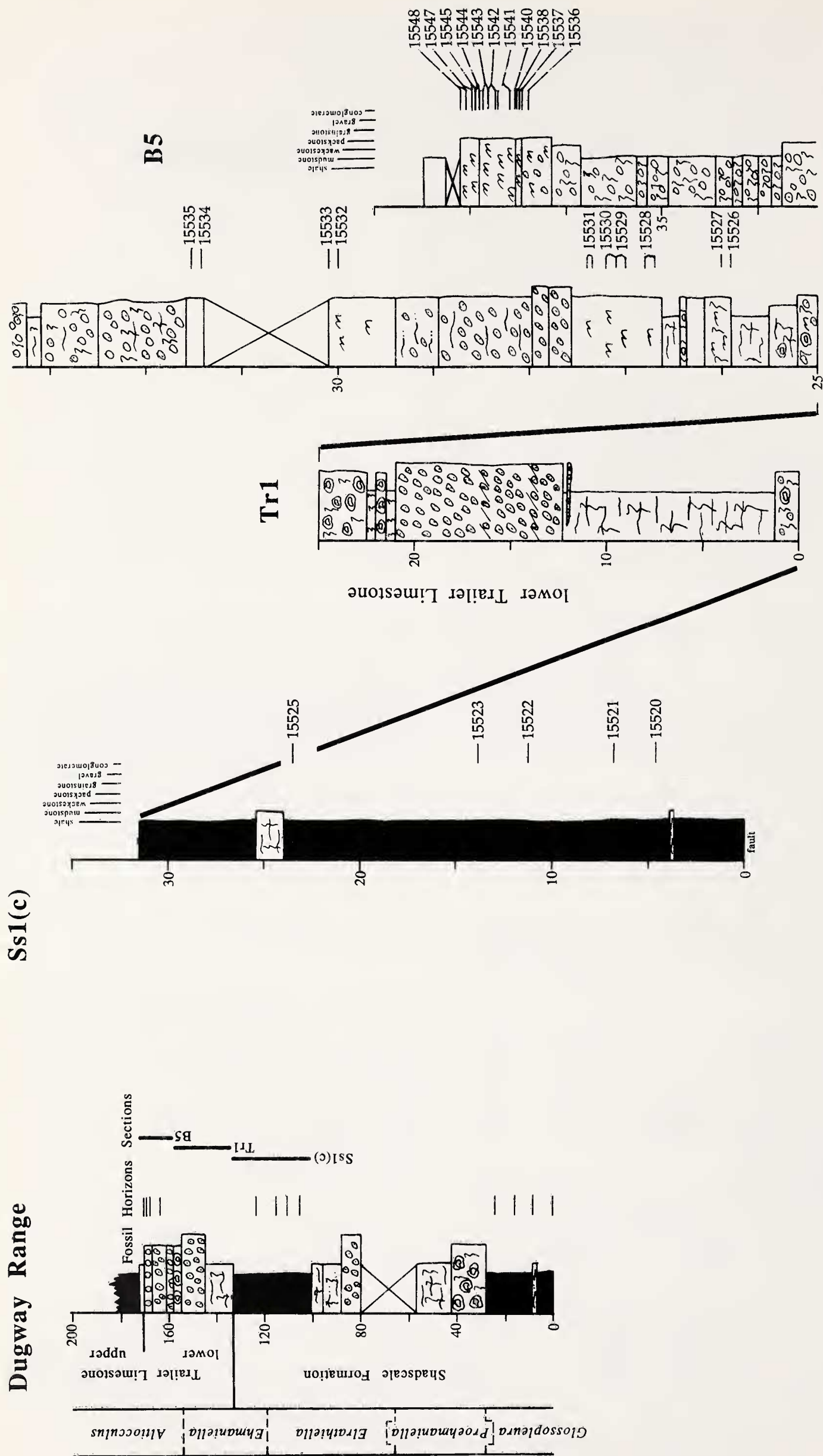


Figure 86. Generalized stratigraphic section of the *Ehmaniella* Biozone in the Dugway Range, Utah, and detailed sections Ss1(c), Tr1, and B5 showing LACMIP localities. (See Fig. 79 for lithologic symbols.)

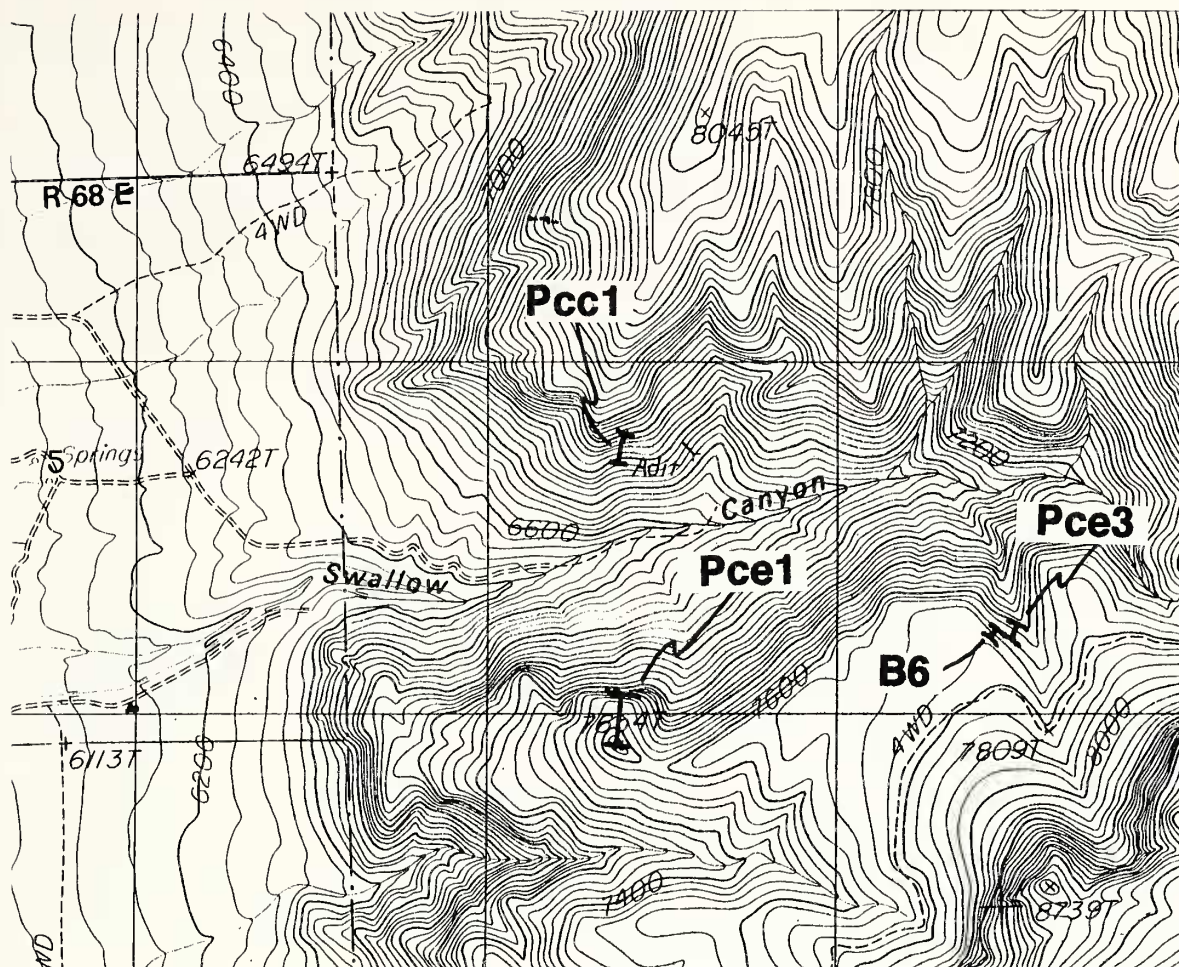


Figure 87. Location of stratigraphic sections in the Snake Range, Nevada. From Minerva Canyon 7.5' Quadrangle (1987). Contour interval 40 ft.

LACMIP 15532. Lower Trailer Limestone, sections B5 and Tr1, 29.95 m above base of sections.

LACMIP 15533. Lower Trailer Limestone, sections B5 and Tr1, 30.10 m above base of sections.

LACMIP 15534. Lower Trailer Limestone, sections B5 and Tr1, 31.40 m above base of sections.

LACMIP 15535. Lower Trailer Limestone, sections B5 and Tr1, 31.50 m above base of sections.

LACMIP 15536. Lower Trailer Limestone, sections B5 and Tr1, 36.40 m above base of sections.

LACMIP 15537. Lower Trailer Limestone, sections B5 and Tr1, 36.50 m above base of sections.

LACMIP 15538. Lower Trailer Limestone, sections B5 and Tr1, 36.54 m above base of sections.

LACMIP 15540. Lower Trailer Limestone, sections B5 and Tr1, 36.56 m above base of sections.

LACMIP 15541. Lower Trailer Limestone, sections B5 and Tr1, 36.61 m above base of sections.

LACMIP 15542. Lower Trailer Limestone, sections B5 and Tr1, 36.75 m above base of sections.

LACMIP 15543. Lower Trailer Limestone, sections B5 and Tr1, 36.80 m above base of sections.

LACMIP 15544. Lower Trailer Limestone, sections B5 and Tr1, 36.94 m above base of sections.

LACMIP 15545. Lower Trailer Limestone, sections B5 and Tr1, 36.97 m above base of sections.

LACMIP 15547. Lower Trailer Limestone, sections B5 and Tr1, 37.03 m above base of sections.

LACMIP 15548. Lower Trailer Limestone, sections B5 and Tr1, 37.10 m above base of sections.

SNAKE RANGE

SECTIONS. Pcc1, Pce1, Pce3, and B6

LOCATIONS. Pcc1—section 4 (projected), T. 11 N., R. 68 E., USGS topographic map Minerva Canyon 7.5'

Quadrangle, Nevada (1987); Snake Range, White Pine County, Nevada (Fig. 87). Pce1—sections 4 and 9 (projected) T. 11 N., R. 68 E., USGS topographic map Minerva Canyon 7.5' Quadrangle, Nevada (1987); Snake Range, White Pine County, Nevada (Fig. 87). Pce3 and B6—section 3 (projected), T. 11 N., R. 68 E., USGS topographic map Minerva Canyon 7.5' Quadrangle, Nevada (1987); Snake Range, White Pine County, Nevada (Fig. 87).

DESCRIPTION. The measured sections in the Snake Range cover an incomplete interval of Member C of the Pole Canyon Limestone (14 m, section Pcc1) and a complete interval of Member E of the Pole Canyon Limestone (89.5 m, section Pce1) (Figs. 88 and 89). Only the lowermost portion of Member D of the Pole Canyon Limestone (6 m, section Pcc1) was measured. A short interval from the uppermost Member E of the Pole Canyon Limestone and lowermost Lincoln Park Formation (4.0 m, section B6) was also measured and collected. The section for Member C of the Pole Canyon Limestone (Pcc1) was measured on the north side of Swallow Canyon, east 0.75 km (0.47 mi) from the mouth of the canyon. The sections for Member E of the Pole Canyon Limestone (Pce1, Pce3, and B6) were measured on the south side of Swallow Canyon, east approximately 0.95 km (0.6 mi, section Pce1) and 2.0 km (1.25 m, sections Pce3 and B6) from the mouth of the canyon.

FOSSIL LOCALITIES.

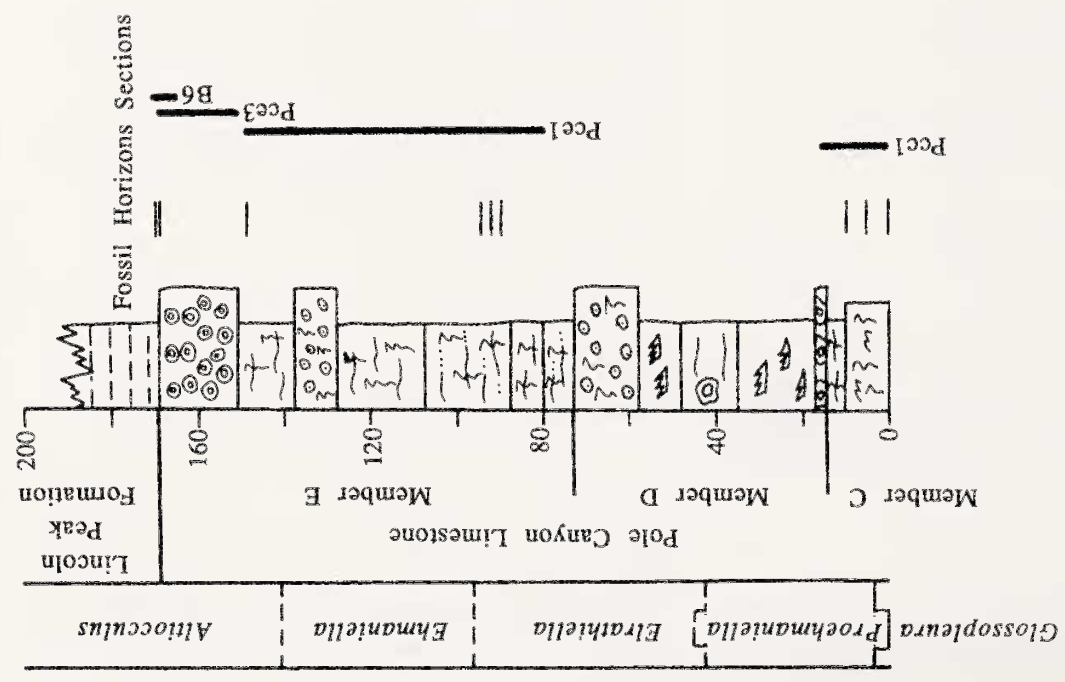
LACMIP 15549. Pole Canyon Limestone, Member C,
section Pcc1, float.

LACMIP 15550. Pole Canyon Limestone, Member C, section Pcc1, 8.5 m above base of section.

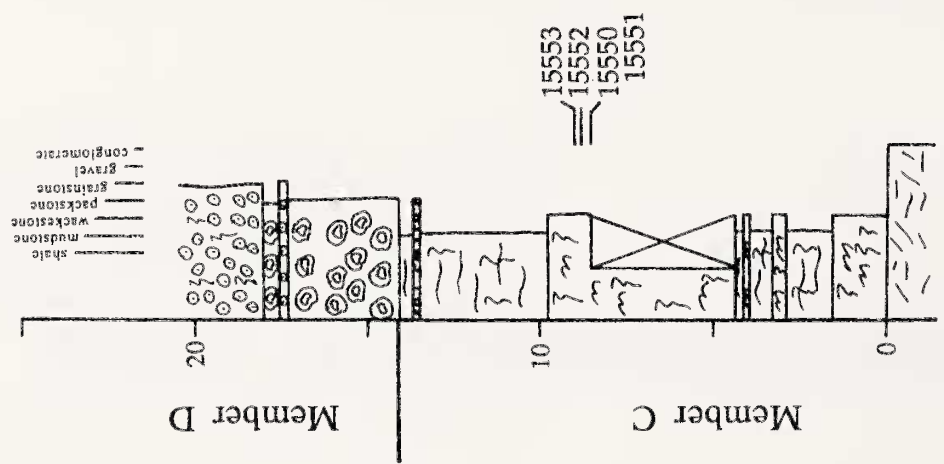
LACMIP 15551. Pole Canyon Limestone, Member C, section Pcc1, 8.5 m above base of section, float.

LACMIP 15552. Pole Canyon Limestone, Member C, section Pcc1, 8.8 m above base of section.

Snake Range



Pcc1



Pcc1

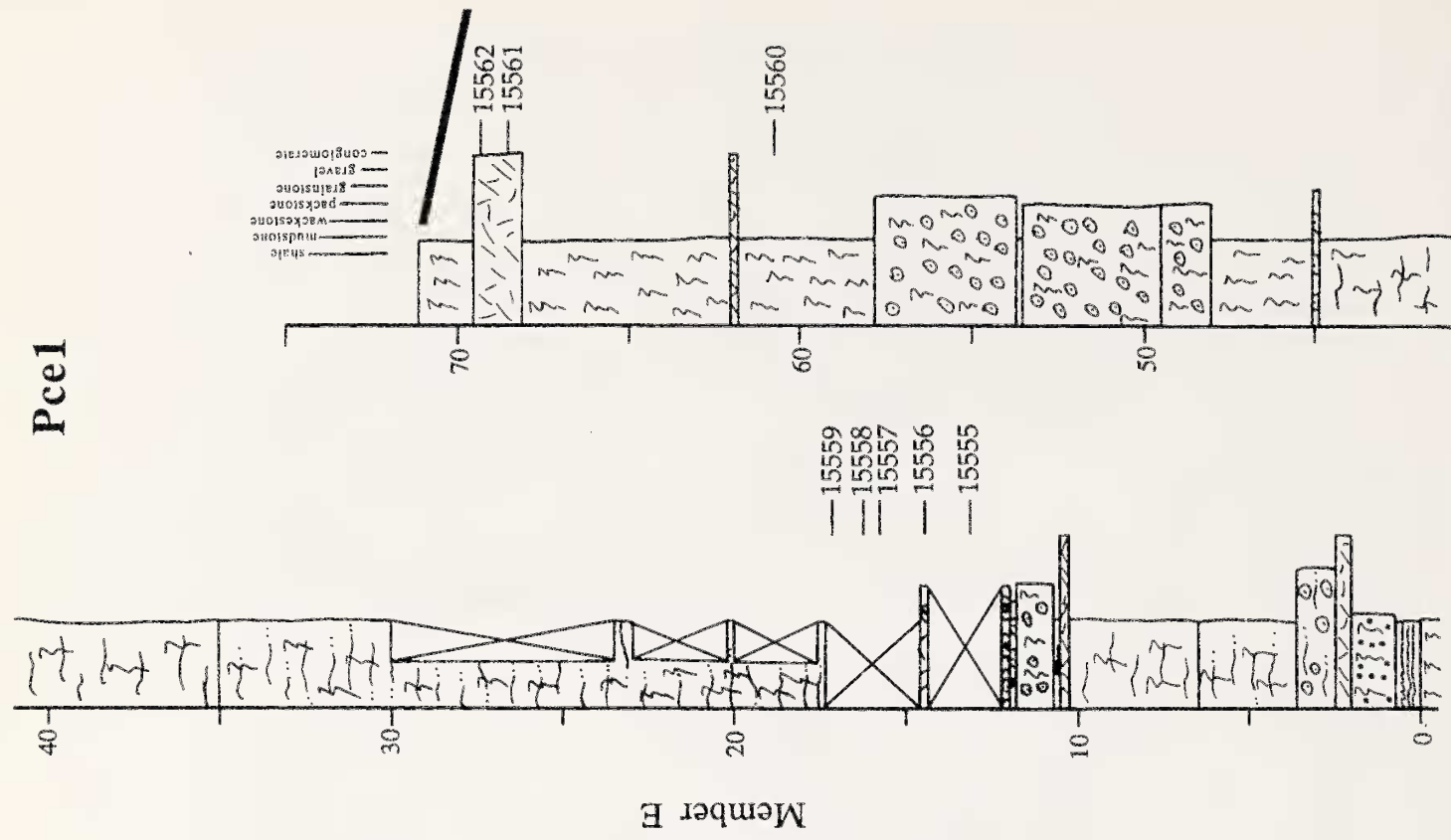


Figure 88. Generalized stratigraphic section of the *Ehmaniella* Biozone in the Snake Range, Nevada, and detailed sections Pcc1 and Pcc1 showing LACMIP localities. (See Fig. 79 for lithologic symbols.)

Pce3

B6

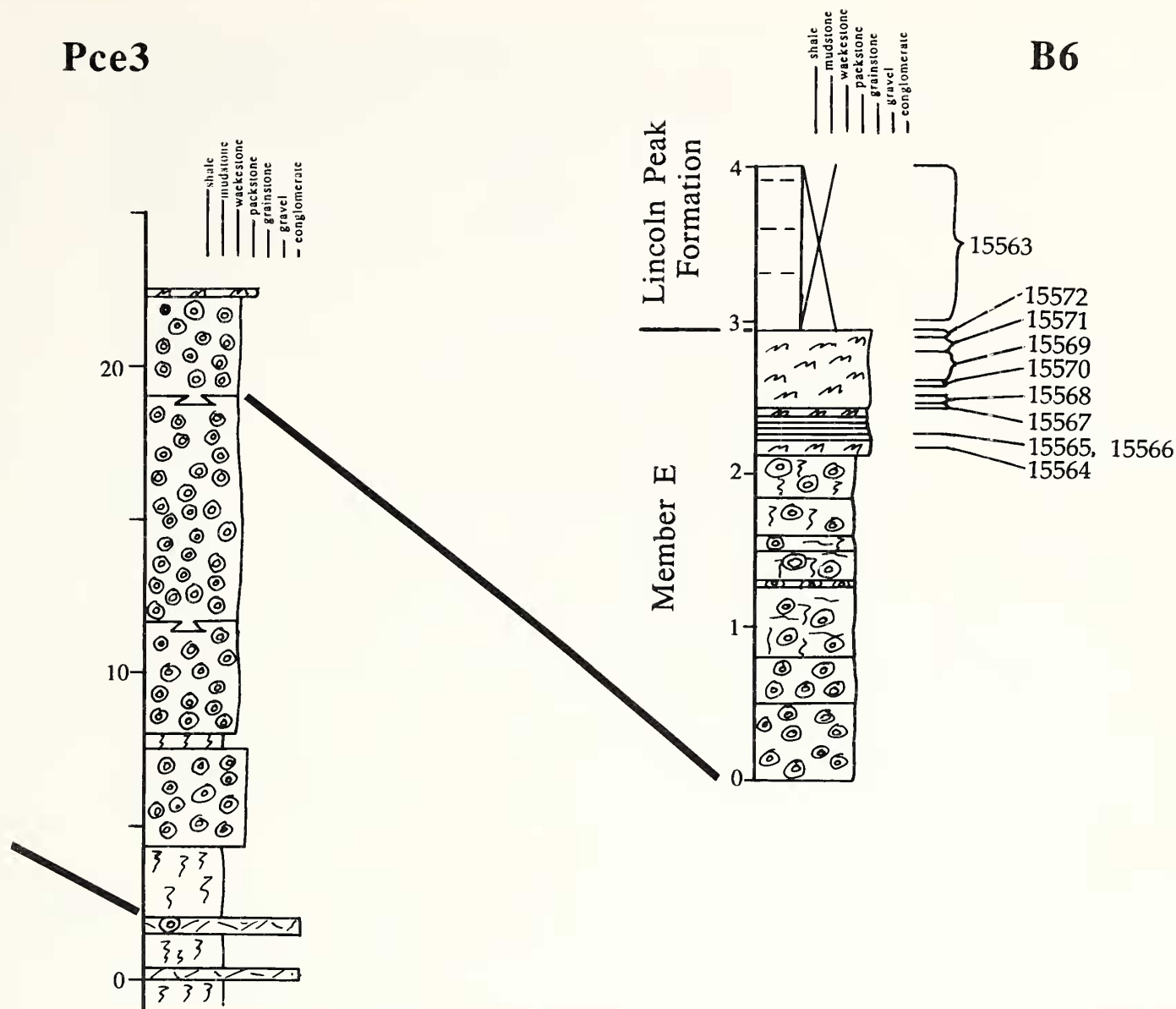


Figure 89. Detailed sections Pce3 and B6 from the Snake Range showing LACMIP localities. (See Fig. 79 for lithologic symbols.)

- LACMIP 15553. Pole Canyon Limestone, Member C, section Pcc1, 9.0 m above base of section.
- LACMIP 15554. Pole Canyon Limestone, Member E, section Pce1, float near base of section.
- LACMIP 15555. Pole Canyon Limestone, Member E, section Pce1, 12.2–17.0 m above base of section, float.
- LACMIP 15556. Pole Canyon Limestone, Member E, section Pce1, 14.5 m above base of section.
- LACMIP 15557. Pole Canyon Limestone, Member E, section Pce1, 15.7 m above base of section, float.
- LACMIP 15558. Pole Canyon Limestone, Member E, section Pce1, 16.3 m above base of section, float.
- LACMIP 15559. Pole Canyon Limestone, Member E, section Pce1, 17.2 m above base of section, float.
- LACMIP 15560. Pole Canyon Limestone, Member E, section Pce1, 60.7 m above base of section.
- LACMIP 15561. Pole Canyon Limestone, Member E, section Pce1, 68.5 m above base of section.
- LACMIP 15562. Pole Canyon Limestone, Member E, section Pce1, 69.5 m above base of section.
- LACMIP 15563. Lincoln Peak Formation, section B6, first meter of formation (2.9–4.0 m above base of section), float.
- LACMIP 15564. Pole Canyon Limestone, uppermost Member E, section B6, 2.19 m above base of section.
- LACMIP 15565. Pole Canyon Limestone, uppermost Member E, section B6, 2.25 m above base of section, collected along strike.

- LACMIP 15566. Pole Canyon Limestone, uppermost Member E, section B6, 2.25 m above base of section.
- LACMIP 15567. Pole Canyon Limestone, uppermost Member E, section B6, 2.43 m above base of section.
- LACMIP 15568. Pole Canyon Limestone, uppermost Member E, section B6, 2.47 m above base of section.
- LACMIP 15569. Pole Canyon Limestone, uppermost Member E, section B6, 2.60 to 2.80 m above base of section.
- LACMIP 15570. Pole Canyon Limestone, uppermost Member E, section B6, 2.55 m above base of section.
- LACMIP 15571. Pole Canyon Limestone, uppermost Member E, section B6, 2.85 m above base of section.
- LACMIP 15572. Pole Canyon Limestone, uppermost Member E, section B6, 2.93 m above base of section.
- USGS 1982-CO. Pole Canyon Limestone, Minerva District.

PATTERSON PASS (SOUTHERN SCHELL CREEK RANGE)

SECTIONS. Pce4 and B7.

LOCATION. Section 36 (projected), T. 9 N., R. 64 W., USGS topographic map Milk Ranch Spring 7.5' Quadrangle, Nevada (1973); Southern Schell Creek Range, Lincoln County, Nevada (Fig. 90).

DESCRIPTION. The measured sections in the southern Schell Creek Range cover Member E (148 m, section

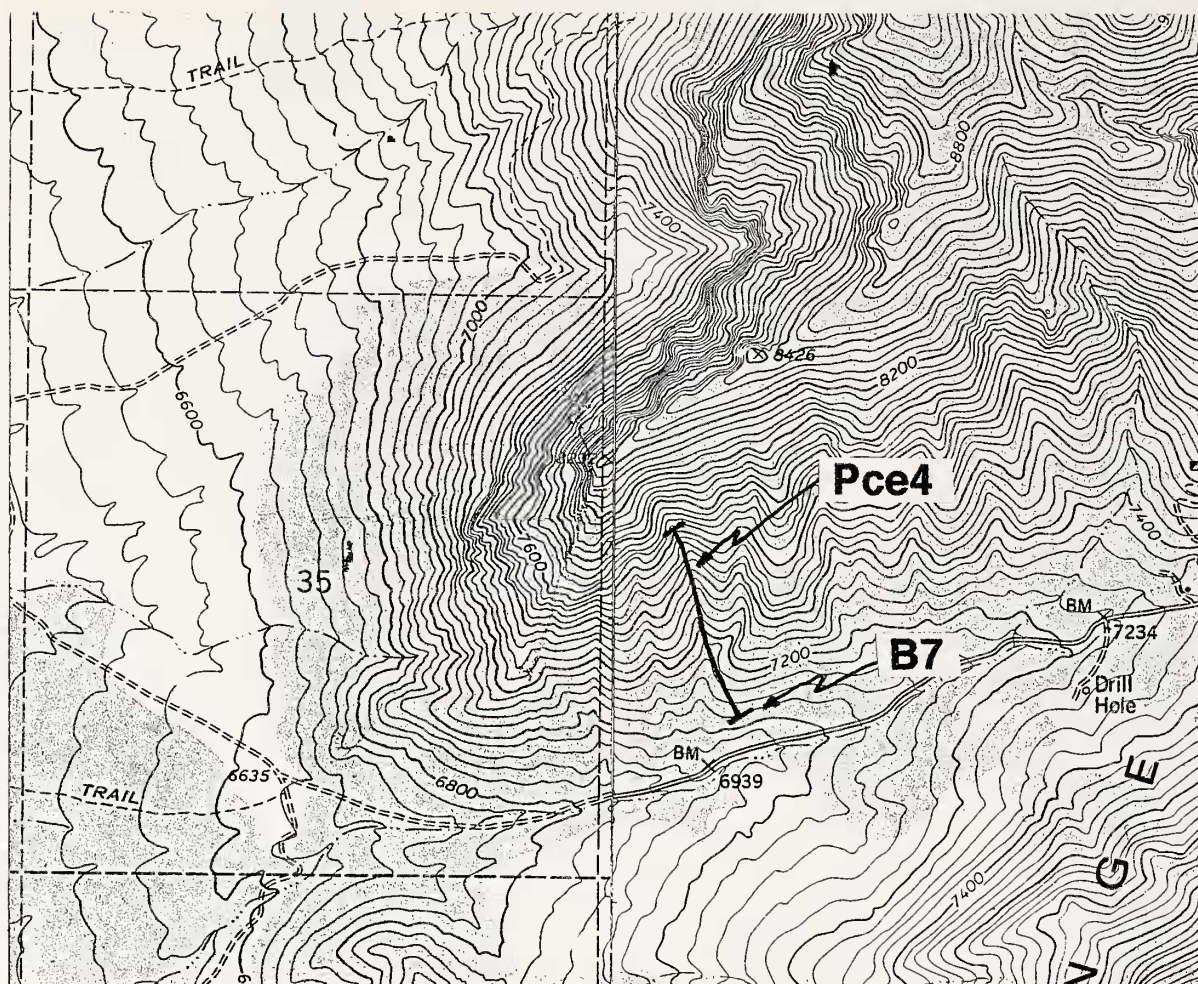


Figure 90. Location of stratigraphic sections in the Patterson Pass area, southern Schell Creek Range, Nevada. From Single Pass SE (1969) and Milk Ranch Spring (1973) 7.5' quadrangles. Contour interval 40 ft.

Pce4) of the Pole Canyon Limestone and a short interval from the uppermost Member E of the Pole Canyon Limestone and lowermost Patterson Pass Shale (2.5 m, section B7) (Fig. 91). The sections for Member E of the Pole Canyon Limestone (Pce4 and B7) were measured on the north side of canyon approximately 1.4 km (0.9 mi) west of Patterson Pass.

FOSSIL LOCALITIES.

- LACMIP 15573. Pole Canyon Limestone, Member E, section Pce4, 7.7 m above base of section.
- LACMIP 15574. Pole Canyon Limestone, Member E, section Pce4, 8.2 m above base of section.
- LACMIP 15575. Pole Canyon Limestone, Member E, section Pce4, 8.8 m above base of section.
- LACMIP 15576. Pole Canyon Limestone, Member E, section Pce4, 13.5 m above base of section.
- LACMIP 15577. Pole Canyon Limestone, Member E, section Pce4, 17.4 m above base of section.
- LACMIP 15578. Pole Canyon Limestone, Member E, section Pce4, 17.5 m above base of section.
- LACMIP 15579. Pole Canyon Limestone, Member E, section Pce4, 20.4–22.5 m above base of section, float.
- LACMIP 15580. Pole Canyon Limestone, uppermost Member E, section B7, 0.45 m above base of section.
- LACMIP 15581. Patterson Pass Shale, uppermost Member E, section B7, 0.53 m above base of section.

NORTHERN EGAN RANGE

SECTIONS. El1 and B8.

LOCATION. T. 22 N., R. 63 E., USGS topographic map Borchert Springs, Nevada 7.5' Quadrangle, Nevada

(1982); northern Egan Range, White Pine County, Nevada (Fig. 92).

DESCRIPTION. The measured section in the northern Egan Range covers an incomplete interval of the Eldorado Formation (240 m, section El1) and Secret Canyon Formation (5 m, section El1) (Fig. 93). A short interval from the shale unit at the base of the measured section (1.5 m, section B8; not the base of the Eldorado Formation) was also measured and collected. The lower portion of the section is located on an east–west canyon side and the upper portion is located on the adjacent ridge to the north, on the east face of the northern Egan Range, approximately 2.0 km (1.25 mi) due west of a location on road at approximately 16.6 km (10.4 mi) south of Cherry Creek. The locations of the sections on the locality map are approximate; they were originally plotted on the Ely, Nevada; Utah, USGS 2° Quadrangle (1971).

FOSSIL LOCALITIES.

- LACMIP 15582. Eldorado Formation, section El1, float.
- LACMIP 15583. Eldorado Formation, section El1, 2.0 m above base of section, found along strike, float.
- LACMIP 15584. Eldorado Formation, section El1, 4.0–7.0 m above base of section, float.
- LACMIP 15585. Eldorado Formation, section El1, 5.3 m above base of section, found 3 m along strike.
- LACMIP 15586. Eldorado Formation, section El1, 5.7 m above base of section, found 3 m along strike.
- LACMIP 15587. Eldorado Formation, section El1, 5.7 m above base of section.
- LACMIP 15588. Eldorado Formation, section El1, 6.5 m above base of section, found 4 m along strike.

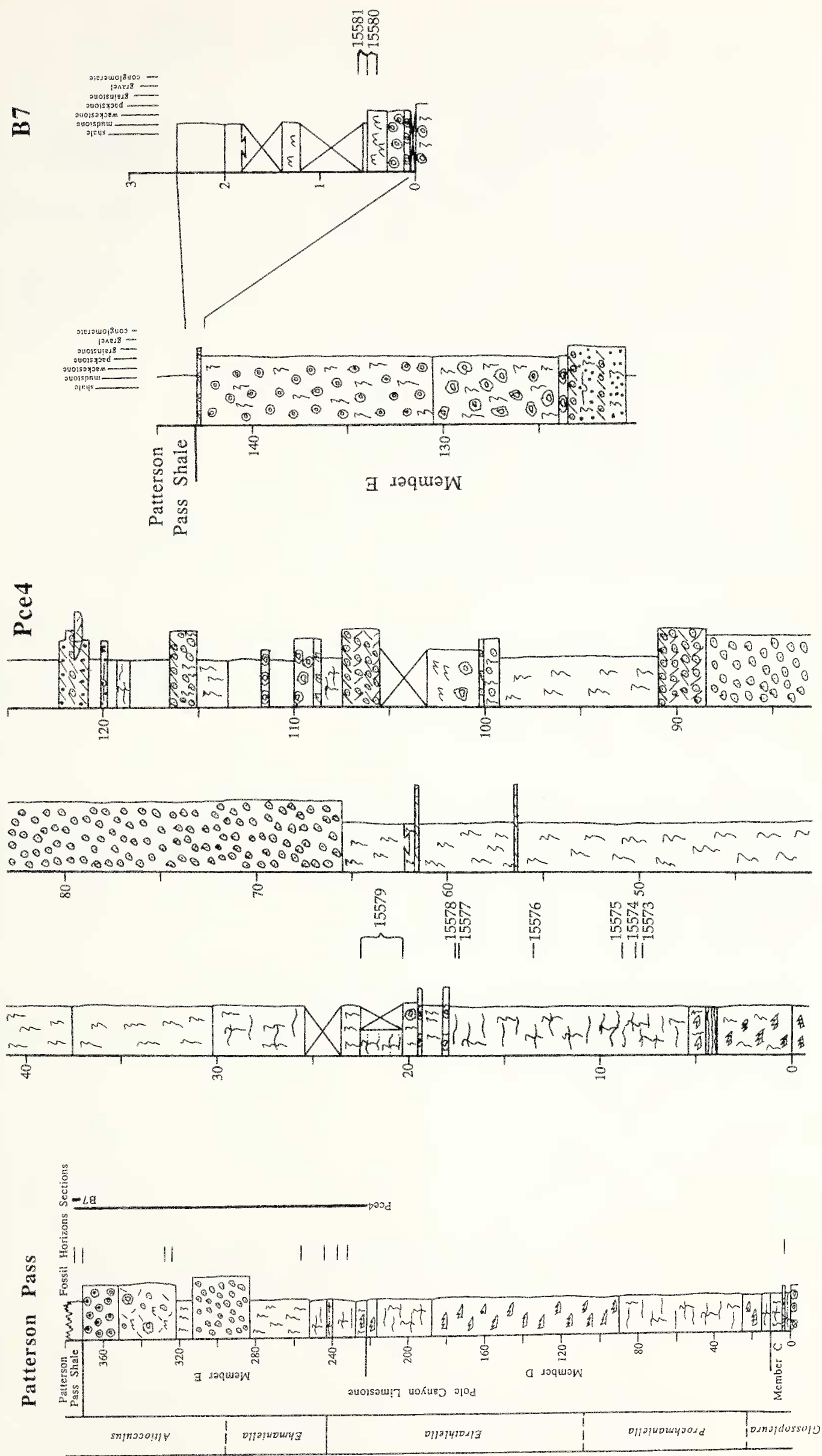


Figure 91. Generalized stratigraphic section of the *Ehmaniella* Biozone in the Patterson Pass area, Nevada, and detailed sections Pce4 and B7 showing LACMIP localities. (See Fig. 79 for lithologic symbols.)

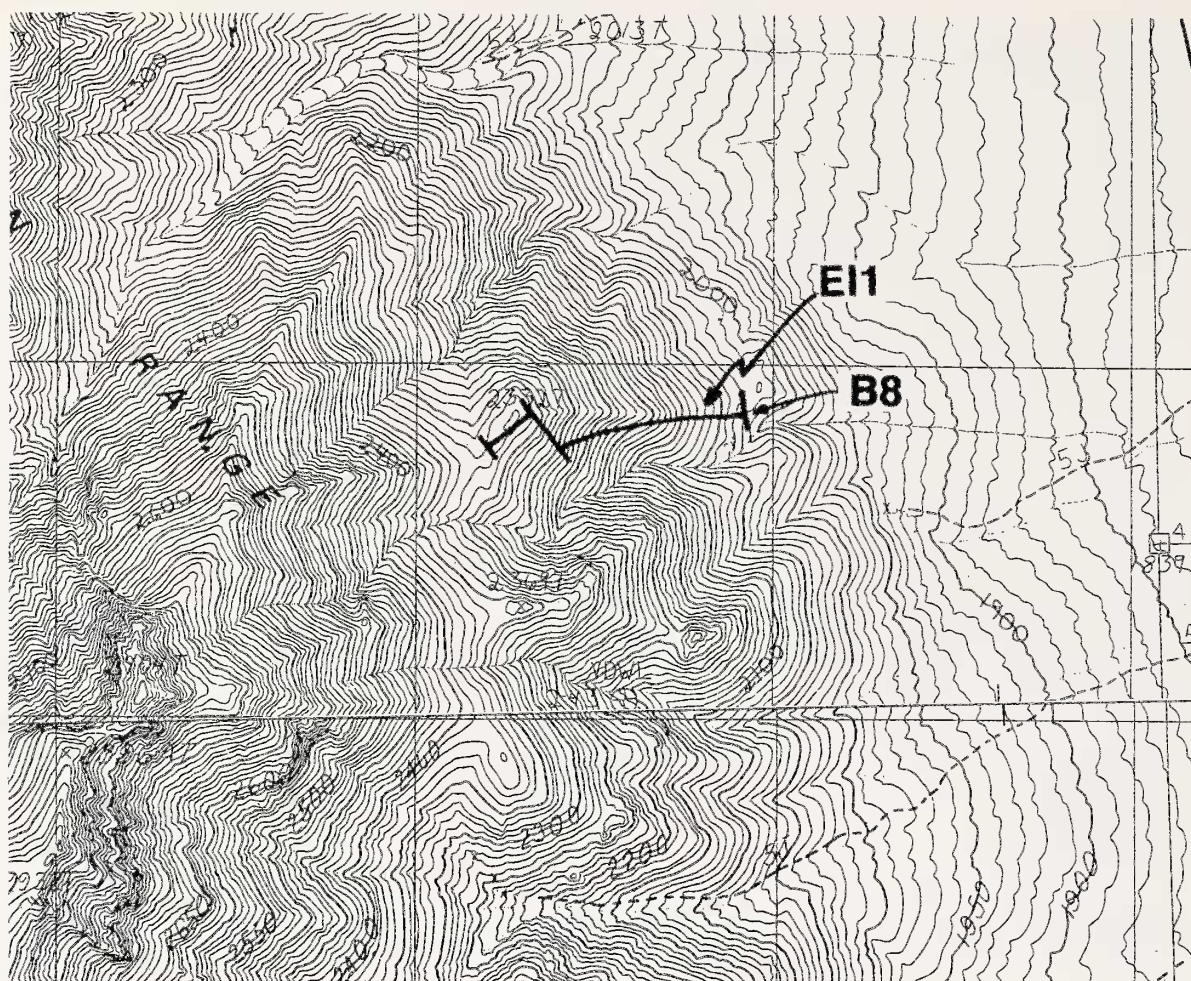


Figure 92. Location of stratigraphic sections in the northern Egan Range, Nevada. From Borchert Springs (1982) and Monte Neva Hot Springs (1982) 7.5' quadrangles. Contour interval 10 m.

- | | |
|---|--|
| LACMIP 15589. Eldorado Formation, section E11, 8.3 m above base of section, found 4 m along strike. | LACMIP 15602. Eldorado Formation, section E11, 237.0 m above base of section. |
| LACMIP 15590. Eldorado Formation, section E11, 115.0 m above base of section. | LACMIP 15603. Eldorado Formation, section E11, 238.5 m above base of section. |
| LACMIP 15591. Eldorado Formation, section E11, 148.5 m above base of section. | LACMIP 15604. Eldorado Formation, section E11, 238.5 m above base of section, found approximately 10 m along strike. |
| LACMIP 15592. Eldorado Formation, section E11, 148.7 m above base of section. | LACMIP 15605. Eldorado Formation, section E11, 238.7 m above base of section, found approximately 10 m along strike. |
| LACMIP 15593. Eldorado Formation, section E11, 149.6 m above base of section. | LACMIP 15606. Eldorado Formation, section E11, 238.8 m above base of section. |
| LACMIP 15594. Eldorado Formation, section E11, 190.0 m above base of section. | LACMIP 15607. Eldorado Formation, section B8, 0.00 m above base of section. |
| LACMIP 15595. Eldorado Formation, section E11, 190.2 m above base of section. | LACMIP 15608. Eldorado Formation, section B8, 0.30 m above base of section. |
| LACMIP 15596. Eldorado Formation, section E11, 191.0 m above base of section. | LACMIP 15609. Eldorado Formation, section B8, 0.45 m above base of section. |
| LACMIP 15597. Eldorado Formation, section E11, 191.5 m above base of section. | LACMIP 15610. Eldorado Formation, section B8, 0.50 m above base of section. |
| LACMIP 15598. Eldorado Formation, section E11, 192.5 m above base of section. | LACMIP 15611. Eldorado Formation, section B8, 0.60 m above base of section. |
| LACMIP 15599. Eldorado Formation, section E11, 206.0 m above base of section. | LACMIP 15612. Eldorado Formation, section B8, 0.80 m above base of section. |
| LACMIP 15600. Eldorado Formation, section E11, 228.5 m above base of section. | LACMIP 15613. Eldorado Formation, section B8, 0.90 m above base of section. |
| LACMIP 15601. Eldorado Formation, section E11, 231.0 m above base of section. | |

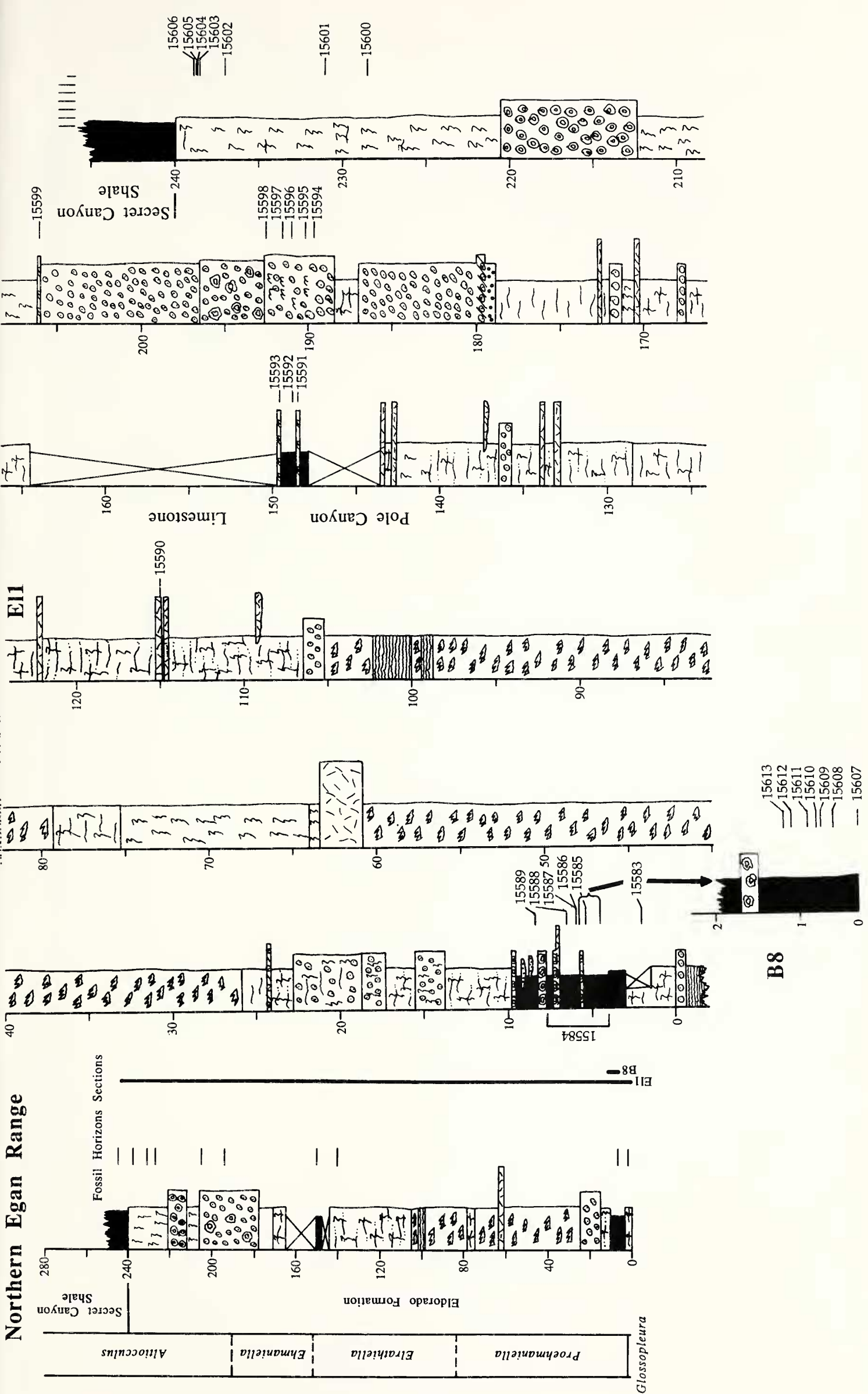


Figure 93. Generalized stratigraphic section of the *Ehmaniella* Biozone in the northern Egan Range, Nevada, and detailed sections B8 and E11 showing LACMIP localities. (See Fig. 79 for lithologic symbols.)